POWER

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James Watt

BY RUFUS T. STROHM

His was the dauntless faith, the vision clear and certain,
That made sublimely real the substance of a dream;
His was the daring hand that swept aside the curtain,
Revealing to his fellows the potency of steam.
Then Earth began to pour in swiftly growing measures
The metals from her mountains, the fuel from her mines,
To meet the needs of men and multiply their pleasures
And mold their weak achievements in mightier designs.

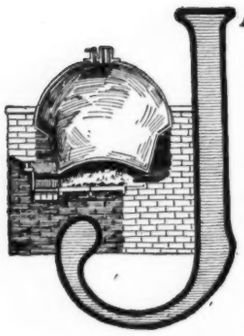
He blazed a virgin trail for other feet to follow,
And slow-paced human progress sped on a thousand years;
For railroads flung their bands o'er every hill and hollow
To link with teeming cities the uttermost frontiers;
While vessels staunch and trim, the fickle winds disdaining,
Went weaving foaming wakes where restless oceans roll,
Their pennoncels of smoke and plumes of vapor staining
The vaulted dome of heaven from distant pole to pole.

His genius unlocked the barred and bolted prison
That held in age-long fetters the giant, Industry,
And factories and mills with magic speed have risen
In numbers that outrival the rocks that ring the sea,
While myriad machines of intricate devising
Receive the million products of forest, mine and mart
And fashion them with skill and energy surprising
For every need of warfare and every peaceful art.

A century has passed while his brave soul lay sleeping
Where Handsworth's parish church uprears its ivied walls,
But though the grave may hold his dust within its keeping,
His spirit lives wherever a chimney's shadow falls.
The roar of mighty engines, above the workshop's clamor,
The whir of driven pulleys, the growl of gnashing gears,
The deep-toned clang of steel beneath the beating hammer
Must fall like pleasant music upon his ghostly ears.

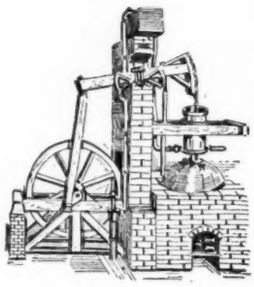
James Watt

By C. H. BROMLEY



JAMES WATT is dead one hundred years today, August 19. No man in all history, perhaps, has exerted greater influence upon industrial civilization—aye, upon all civilization. One need reflect but a moment to appreciate that without steam power we would today be living in an age of baron and serf, with agriculture the main pursuit of all peoples, with woeful illiteracy and hard, hand labor for all who labored, with crude, slow transportation, likely without the development and use of electricity and refrigeration.

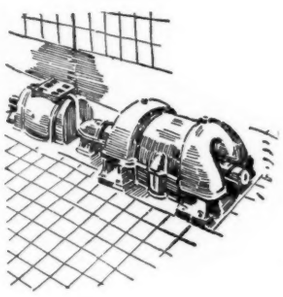
Studying steam-engine development prior to, contemporaneous with and succeeding Watt, in the light of the foreign policy and commercial activity of England seems to warrant a belief that the steam engine was a most powerful factor in the rapidly rising superiority of England in the world's commerce. Before the introduction of the steam engine England had acquired world dominance by sea power. The last great naval force mobilized for the invasion of England was the famous Spanish Armada, which Drake destroyed in 1588. But this was before the steam engine. During the frequent wars between France and Spain, which lasted from the Thirteenth Century until the complete disintegration of Spain as a world power, the English were taking advantage of every factor in world commerce control. Yet every people of war-ridden Europe were suffering great privations, just as they are now. At this time came the steam engine like a God-given gift to multiply many times the productive power of the Island Kingdom, to make profitable the working of abandoned coal mines—in short, to make England the savior of the world as far as commodities go, just as our food and other commodities saved the cause of civilization in this war. England ruled the sea and so with expediency and dispatch carried her commodities to the four corners of the earth. Some years later, America, great in world sea commerce, scoffed at the steam-propelled ship, while England, appreciating its superiority over the sail, built great fleets which, up until now, have practically swept America from the seas.



In these days of great labor unrest it is of interest to recall the effect of the steam engine upon labor. From 1811 to 1816 severe riots occurred at Nottingham, Yorkshire, Lancashire, Derbyshire and Leicestershire among the working people because they feared the steam engine would bring misery due to the change from hand to machine work which it was bringing about. These rioters were known as the Laddites.

Men, like things, are composites of what has gone before—they are what their ancestors and the arts have made them. So, too, with Watt. To know him we must know what he was and what physical science was when he began to utilize natural laws. Watt was born at Greenock, Scotland, Jan. 19, 1736, the son of a small merchant. At 19 he went to London to learn the trade of "philosophical instrument maker." Now leave him and pick up the thread of physical discoveries and inventions long before his time. Galileo, famous in astronomical and ecclesiastical history, suspects the existence of atmospheric pressure in 1640. In 1643 Torricelli, his student, proves Galileo was right and demonstrates atmospheric pressure. It was by atmospheric pressure that early steam engines were operated. The Marquis of Worcester in 1663 made a steam engine in which steam was expanded to force up water in a jet. Captain Savery made a pump in 1699 in which he employed the principles of expansion and condensation of steam. Newcomen made himself immortal by greatly perfecting the idea of Papin in 1710, making a type of pumping engine which was the most valuable engine commercially ever invented. Newcomen had the advantage of many minds, for in 1663 the Royal Society with such men as Sir Isaac Newton, Boyle, Dr. Hooke, Dr. Wallis and others, was formed for the promotion of physical science. Newcomen derived especial benefits from the work of Denys Papin, a French physician, who became a member of the Royal Society in 1680 and for ten years devoted his life to the physics of fluids. He was the first to raise a piston in a cylinder by means of vapor and atmospheric pressure—a principle which is basic in the reciprocating steam engines and even turbines of today. Then there was the notable work written by Solomon De Caus in 1623 on the use of nature's forces in machines. The foregoing are some of the chief problems that Watt found already worked out for him when, as philosophical-instrument maker to the University of Glasgow, in 1764, he was given a small Newcomen engine to repair. Here in the quiet of his laboratory, while he was tinkering with this "job," were to develop the ideas which were to commercialize steam power and revolutionize civilization.

He found soon that the steam consumption of Newcomen's engine could be greatly decreased by keeping the cylinder as hot as the steam used in it and keeping the condensed steam at 100 deg. F. or lower. But the properties of steam were not known. Dr. Cullen had found that water in a vacuum boiled at a lower temperature than at atmospheric pressure. So with this knowledge, supplemented by his own researches, Watt found out much about the properties of steam, and his work was the most authoritative of his time. He saw that the losses occasioned by initial condensation could to a great degree be overcome by creating a vacuum for the engine in a separate vessel connected to the engine by a pipe and by jacketing the engine cylinder. So he invented the jet condenser.



Jan. 5, 1769, Watt took out his first patent on the steam engine. He then went in business with John Roebuck, owner of the Carron Iron Works. Roebuck failed and Watt temporarily gave

James Watt
1736–1819

up steam engineering and did civil engineering for the Crown. When his patent had nearly expired, he met Matthew Bolton, of the Soho Works, and together by act of Parliament they got the patent extended for 25 more years. This was in 1775. Now his work began in earnest. In 1782 he introduced expansive force of steam to a piston instead of merely using steam to fill a cylinder, displace the air and then condense the steam so atmospheric pressure would drive it. This was a big and bold step. Then quickly came the throttle valve, cutoff, engine indicator and centrifugal governor.

Others were quick to appreciate and take advantage of the possibilities of steam pressures above atmospheric, a field initiated by Watt, but not carried far by him. In fact, Watt was hostile toward "high steam pressures." Trevithick, a contemporary of Watt, wanted to use a pressure of something like 40 lb. gage, and Watt, either because he believed it dangerous or because of purely commercial reasons, took the matter to Parliament, whose authority he invoked to suppress the use of such a dangerous pressure.

Naturally, with the realization that these so-called high pressures were practicable, engineering saw the value of compounding, and Wolf in 1805 brought out a compound engine. This also brought protests from Watt.

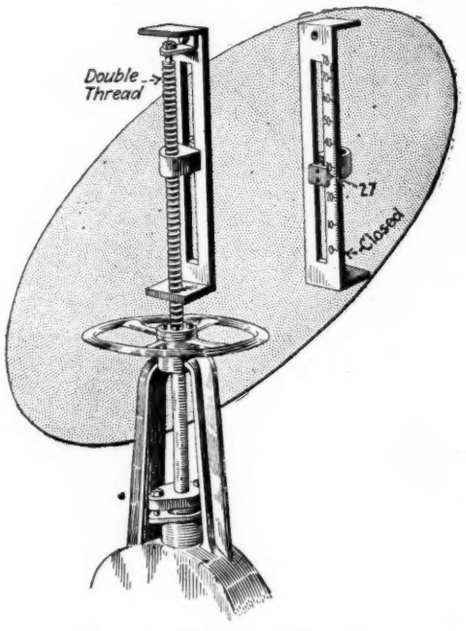
Watt may have really believed these two great advances were dangerous. But if one has in mind that Watt was the greatest engineer of his time, that he knew the properties of steam perhaps better than any other man, that he and Bolton were taking as payment, or at least part payment for their engines, the savings they effected over the Newcomen pumping engines then in use, one becomes convinced that it was competitive, more than scientific reasons, which made Watt hostile to further increase in pressures and to compounding. It was in 1784 that Watt succeeded in adapting the piston to produce continuous circular motion of a shaft. Then, of course, the steam engine became applicable to all industry, whereas previously it had found application solely to pumping water from flooded and abandoned coal mines. It is, therefore, reasonable to suppose that Bolton and Watt did not want more competition or engines of greater economies than their make offered to the many large industries which needed the steam engine.

In Manchester in 1824 there were about 240 "large" steam engines, each of about 15 to 20 hp. There is now operating in the Seventy-fourth Street Station of the Interborough Rapid Transit Co., New York City, a 60,000-kw. turbine. Watt's early engines required about 9 lb. of Newcastle coal per horsepower-hour. Modern turbines require but a pound.

It is 150 years since Watt patented his first engine, but considering the high state to which he had perfected it before he died, one may say that, commercially, no other great era in steam engineering came until 133 years later, when in 1902 large—for that time—steam turbines were successfully applied at Hartford, Conn. The writer does not forget Porter, Corliss, Sweet, Leavitt, Reynolds, and others; their work marked great improvements, but ushered in no new type of prime mover nor changed extensively the fundamental type completed by Watt. It is unfortunate that lack of space forbids reviewing, generally, the progress in steam-boiler practice in the same period, for here, too, great strides have been made which have added materially to the improved performance of steam-power plants.

Injection-Water-Valve Gage

Engineers recognize the value of knowing how much the injection-water valve is open. Numerous devices have been used for this purpose, and the accompanying illustration shows a rig one engineer designed and used. Attached to the top of the valve handwheel is a flange in which is screwed a double-threaded stem and which



VALVE-OPENING INDICATOR

is steadied at the top by an angle-iron bearing. In front of the screw is a gage board slotted so that a marker can slide from the top to the bottom, as shown in the illustration. Where this rig was used, it requires 78 turns of the handwheel to open the valve wide. The running position at the time the sketch was made was 28 turns. The general arrangement is shown, and the gage board can be secured either to the valve proper or to an overhead source. The value of the arrangement is obvious.

Delegates to the Convention, National Association of Stationary Engineers

Power will again this year try to publish the photos of attending delegates in its convention fun maker, the *Power Pup*. Also each delegate will be given a package of cards bearing his photograph, name, position, association and city. But to do this we must have either your photograph or the electrotype we gave you at previous conventions, together with name, position, association and city.

All photographs must be of post-card size and show only head and shoulders—the three for a quarter kind will do. No photos will be accepted at Huntington, as Huntington affords no facilities for making electrotypes.

Please call this to the attention of your fellow-delegates and mail your photograph or electrotype today. These cards will help you to associate the names with the faces of the many new friends you will make. Address, Editor of *Power*, Tenth Avenue at Thirty-sixth Street, New York City.

Pulverized Coal as a Fuel*

BY N. C. HARRISON

The author first reviews some of the uses of pulverized coal in the industries, such as the cement, steel and copper industries. The use of pulverized coal in stationary boiler plants is discussed, five determining factors in the successful operation of such a plant being taken up in detail. As compared with mechanical-stoker plants the advantages of the pulverized-coal plant are enumerated and certain precautions to be observed with the latter type of plant are brought out. A report of a test of a 468-hp. Edge Moor boiler with pulverized-coal equipment is included in the paper and the efficiency obtained is compared with the efficiency of a stoker-fed boiler in the same plant, a greater net efficiency being found in the pulverized-coal plant.

PULVERIZED coal was first used in the United States about 26 years ago for the economical burning of the cement rock in the rotary kilns of the portland-cement industry. Somewhere between 30 and 50 million tons of pulverized coal have been used to date in the manufacture of cement alone. There is now being used approximately 6 million tons annually. A total of approximately ten million tons of pulverized coal is burned annually in the United States in industries.

Generally speaking, coals which would give the most satisfactory results would be those in which the ash content would be less than 10 per cent., the volatile averaging between 30 and 40 per cent. and the fixed carbon between 40 and 50 per cent. The sulphur content should be low, although coal with a sulphur content running as high as 4½ to 5 per cent. is being burned in pulverized form under boilers without any detrimental results. The ash should have a high melting point. These statements, however, are tentative, as excellent results have been obtained from all sorts of coals, differing widely from the ideal analysis stated.

From Texas to Edmonton, Alberta, the country is underlaid with various grades of lignites, low-grade mineral coals with high moisture content and of such a nature that the ash would melt or flow down on the grates, thereby preventing the highest efficiency from being obtained. They are of such a nature that their use in gas producers is not very satisfactory, so that until the development and burning of these coals in pulverized form was an assured success they were not used in as large quantities as is now possible.

Coal must be pulverized so that at least 95 per cent. will pass through a 100-mesh sieve having 10,000 openings to the square inch, or in terms of dimension 95 per cent. must be less than one two-hundredth of an inch cube.

A cubic inch of coal pulverized so that 95 per cent. will pass through a 100-mesh sieve will contain over 200 million particles, none of which will be greater than one one-hundredth of an inch cube, and a large percentage will be less than one six-hundredth of an inch cube. A cubic inch of coal has a superficial area of 6 sq.in., but the combined area of these multitudes of small particles shows that when the coal is ground to above-mentioned degree of fineness the superficial area will increase to nearly 30 sq.ft., or an increase in area of approximately 700 times. This increase in area permits perfect and instantaneous combustion. Its rapidity depends directly upon the surface exposure. This is one of the reasons for the grinding.

*Abstract of a paper presented at the Spring Meeting of the American Society of Mechanical Engineers, Detroit, Mich., June, 1919.

COSTS OF PULVERIZING COAL

The cost of the operation of pulverizing coal depends upon four items: First, the amount of moisture that must be expelled from the coal before pulverizing; second, the cost of labor; third, the cost of coal delivered at the pulverizing plant; fourth, the cost of electricity. Table I, issued by a pulverized-coal engineering company, gives the cost of pulverizing plants, including buildings, and costs of pulverizing coal in plants of capacity from 10 to 250 tons per day. These figures include all costs, except interest and depreciation, in the pulverizing plant proper.

TABLE I. COSTS OF COAL-PULVERIZING PLANTS AND COSTS OF PULVERIZING COAL PER TON NET

Tons Daily	Total Cost Pulverizing per Ton	Cost of Plant Including Building	Labor, Hours	Labor, Cost per Ton
10	$0.56	$31,000	10	$0.30
20	.51	31,000	20	.25
30	.49	31,000	30	.23
40	.49	31,000	40	.23
50	.39	37,000	26	.13
60	.39	37,000	30	.13
70	.39	37,000	40	.13
80	.39	37,000	40	.13
90	.39	37,000	46	.13
100	.34	45,000	34	.09
110	.34	45,000	37	.09
120	.33	45,000	40	.08
130	.33	45,000	44	.08
140	.32	50,000	45	.06
150	.32	50,000	47	.06
160	.32	50,000	50	.06
170	.32	50,000	54	.06
180	.32	50,000	57	.06
190	.30	62,000	48	.04
200	.30	62,000	51	.04
210	.30	62,000	53	.04
220	.30	62,000	56	.04
230	.30	62,000	59	.04
240	.30	62,000	61	.04
250	.30	62,000	63	.04

The data on which Table I is based are as follows:
Labor rate: Millers, 30c. per hour; drier firemen, 20c. per hour; common labor, 20c.
Cost of drier fuel: 6c. per net ton, based on 7 per cent. moisture. Coal at $5 per ton delivered.
Evaporation: 6 lb. per lb. of coal burned or 26 lb. of coal per ton.
Repairs: 7c. per net ton. This includes whole pulverizing plant, all machinery.
Power has been based on 12.7c. per ton pulverized, and a consumption of 17 hp.-hr. per ton pulverized at 1c. per kw.-hr. or about $54 per hp. per annum.

We have taken from Table I figures relating to those plants having daily capacities approximately the same as our plant, and by changing labor rates to correspond to our rates have recomputed these figures as given in Table II.

TABLE II. COST OF PULVERIZED COAL PER TON NET

Tons Daily	Total Cost Pulverizing per Ton	Labor, Hours	Labor Cost, per Ton
80	$0.45	40	$0.19
90	.45	46	.19
100	.38	34	.13

Data on which table II is based:
Labor rate: Millers, 40c. per hour; drier firemen, 35c. per hour; common labor, 35c.
Cost of drier fuel: 6c. per net ton, based on 7 per cent. moisture. Coal at $5 per ton delivered.
Evaporation: 6 lb. per pound of coal burned or 26 lb. of coal per ton.
Repairs: 7c. per net ton; this includes whole pulverizing plant, all machinery.
Power has been based on 12.7c. per ton pulverized, and a consumption of 17 hp.-hr. per ton pulverized at 1c. per kw.-hr.
Cost of pulverizing will naturally vary according to local conditions.

Table III shows actual costs at our plant, and these are slightly higher than figures given in Table II.

TABLE III. COSTS OF PULVERIZING COAL PER NET TON AT THE ATLANTIC STEEL COMPANY

	Cost per ton
Daily Output 80 Tons per Day	
Labor	$0.22
Repairs	.19
Power	.134
Drier coal	.0218
Total cost	$0.5658
Daily Output 90 Tons per Day	
Labor	$0.195
Repairs	.19
Power	.134
Drier coal	.0218
Total cost	$0.5408
Daily Output 100 Tons per Day	
Labor	$0.176
Repairs	.19
Power	.134
Drier coal	.0218
Total cost	$0.5218
Total coal pulverized Jan. and Feb., 1919	5275 tons
Power: 17.9 kw.-hr. per ton coal pulv. at ¾ cent	$0.134 per ton
Labor: 1 man 16 hours at $0.40	$6.40
2 men 16 hours at $0.35	11.20
Daily cost	$17.60

(= $0.22 for 80 tons output, $0.195 for 90 tons, $0.176 for 100 tons.)

Drier coal: Cost of drier fuel 2.8c. per ton, based on 2.62 per cent. moisture. Coal at $5 per ton, 6 lb. evaporated per lb. of coal burned or 8.7 lb. per ton of coal pulverized

Repairs: Total repairs for Jan. and Feb.	$1412.16	
Credit	409.69	
Charged		$1002.47 (= $0.19 per ton pulv.)

For the proper combustion of coal under boilers, there are five main points which must be given serious consideration, otherwise the burning of this fuel will not be a success: Coal fineness, size of combustion chamber, necessary air opening, proper damper regulation, clean tubes.

The pulverized coal should run about 96 per cent. through the 100-mesh screen and about 85 per cent. through the 200-mesh screen. If it runs below 80 per cent. through the 200-mesh screen, we notice particles of carbon flying through the air inside of the combustion chamber, and these particles are not completely burned when the gases reach the tubes, and will then deposit themselves on the tubes. Also, these heavy particles in the pulverized-coal mixture will sometimes settle on the bottom of the combustion chamber and will soon build up in the shape of stalactites. This accumulation will continue to build until the bottom of the combustion chamber continues to be raised, until it comes in contact with the flame. These built-up particles will then fuse into a solid mass, which in a very short time will cause a shutdown of the boiler to dig this fused mass out.

Study of Boiler-House Installations

Before installing, or considering the use of pulverized coal under boilers, we must first make a study of our boiler-house installation and know at exactly what rating we wish to operate these boilers, considering any peak load which may develop. We must then design the combustion chamber large enough to take care of the maximum loads which will be developed. After this maximum rating has been determined, we then figure the combustion chamber of a cubical capacity equivalent to approximately 50 cu.ft. per lb. of coal burned per min., or approximately 2½ cu.ft. per hp. developed by the boiler.

If we decide to run this boiler at 150 per cent. of this rating and design the combustion chamber accordingly, the efficiency will not be decreased perceptibly if the boiler is run under this 150 per cent. rating, but if we develop over a 150 per cent. of the rating, we meet difficulties. We have to admit more coal and air to the boiler to develop the greater rating, consequently we need more combustion space, but not having this combustion space, the flames impinge on the brick and cut it away very rapidly. Also, combustion is not complete at the time the gases strike the bottom row of tubes and consequently the gases will pass up the stack unburned. If the gases are not completely burned by the time they reach the first row of tubes, they will not burn later on in the boiler. The size of the combustion chamber should also be so designed that the velocity of the gases should not pass through this combustion chamber at a speed of more than 6 ft. per sec. The mixture of air and coal entering the combustion chamber, as previously stated, should be at as low a pressure as is possible to bring this mixture in in suspension.

Pressure at Which Coal Is Admitted

The pressure at which the pulverized coal is admitted to the furnace is about half an ounce at the nozzle. In some installations the coal falls by gravity from the variable-speed screw conveyor, located on the bottom of the pulverized-coal bin, into a fan air line which carries it into the furnace and also supplies the necessary air for combustion. Some few openings are placed in the front wall of the boiler to give any additional air which may be needed, and a few may also be placed on the side walls of the boiler to protect the brickwork at times.

In other installations the amount of air necessary to convey the coal into the furnace varies, according to the rate at which the boiler is being operated. The balance of the air to burn the coal properly is admitted through adjustable air openings in the front, sides and bottom of the combustion chamber. These openings are made adjustable and are placed on all sides of the combustion chamber to take care of the various grades of coal which may be used. By properly observing the combustion in this chamber, by a little experience the fireman knows at exactly what points to give more or less air needed for combustion.

Accurate Damper Regulation Necessary

To give the proper velocities of gases passing through the combustion chamber, it is necessary that we have accurate damper regulation to take care of the various load conditions. The damper should be so regulated that there is practically a balanced draft inside of the combustion chamber and only a slight vacuum in the first pass, while at the damper itself there should be not more than 0.10 to 0.15 in. With more vacuum than this, it pulls the gases through the combustion chamber too fast, causing them to be unburned before reaching the first row of tubes. This small draft needed at the base of the stack will allow us to operate boilers using pulverized coal with stacks of about 30 to 35 ft. in height.

The keeping clean of the outside of the tubes is necessary with the use of pulverized coal, and they should be blown by means of mechanical soot blowers at least every six hours, and oftener if it is necessary. Also, once every 24 hours by means of a hand-lance steam jet we should blow the bottom of the first row of tubes.

Ash that deposits at the bottom of the combustion chamber should be removed at regular intervals, which

intervals will be determined by the amount of ash in the original coal. If not removed regularly, it will build up until it comes in contact with the flame, when it becomes fused and has to be dug out. But if removed at regular intervals, it can be easily raked out with the ordinary boiler-room ash rake and will not consume more than half an hour per 24 hours, and will not interfere with the operation of the boiler while this is being done.

Advantages of Pulverized Coal

The following are some advantages of pulverized coal as a fuel for boilers over stokers:

1. Much wider variation in the quality of the coal usable is obtained when burning coal in pulverized form. Practically any and all grades of coal can be burned in this form with economy. No stoker will satisfactorily handle all grades of coal.

2. Ability to take care of peak loads almost instantaneously. Its flexibility approaches that of oil or natural gas.

3. The amount of coal that can be burned per square foot of grate surface on stokers is limited so that for increased capacity the boiler setting must be spread out to cover more area. When using pulverized coal, this condition does not exist, for proper furnace conditions can be obtained by increasing the height of the boiler setting or the depth of the combustion chamber.

4. By throwing a switch the entire firing operation ceases, an advantage in case of accident or emergency.

5. Ash is in much better condition to handle. The ash is in the form of a dust or slag, depending upon its melting point.

6. Since there are no grates used when the fuel is burned in pulverized form, we experience no clinkering.

7. Pulverized coal is fired dry, containing less than 1 per cent. of free moisture, whereas coal burned on stokers may vary anywhere from 1 to 10 per cent. of free moisture as fired.

8. Considerable less excess air is necessary for complete combustion. This item is of the utmost importance when making comparisons Less draft is required for pulverized-coal-fired furnaces.

9. All the combustible in the coal is consumed when it is burned in pulverized form, provided the furnace capacity is not exceeded. None of the combustible goes out into the ash pile and therefore fires are eliminated in the ash pile.

10. There is less erosion from sulphur on the boilers due to less moisture in the coal as fired, therefore high-sulphur coals can be burned more readily and without serious result.

11. With furnace properly proportioned and with properly designed burning equipment smokeless operation may be maintained indefinitely.

Some Points to Be Kept in Mind

The following few points must be kept in mind for the successful burning of pulverized coal under boilers:

A boiler furnace using pulverized coal should have as few burners as is possible consistent with good regulation. The burners must be proportioned for the maximum rating of the boilers, and they must be adjustable. Simplicity of design is desirable. It has been found more desirable to introduce coal into the furnace as far away from the side walls as possible so that the rapid continuous expansion of the gases will not develop high velocities in close contact with the furnace refractories. Furnaces under boilers should be proportioned so that the velocity of the gases should not be excessive, particularly at the smallest cross-sectional area of the furnace. Vertical baffles should replace all horizontal baffles.

A boiler of any size can be fired successfully with pulverized coal. Various designs and makes of boilers can be readily arranged for pulverized-coal firing, but those containing the smaller percentage of space for the lodgment of ash are preferable.

Feeders for regulating the flow of pulverized coal to the furnace must be designed so that at all times the variation in quantity will be directly proportional to the speed of the screw and no flooding allowed. The speed of the feeder should be so regulated that operating at its maximum r.p.m. the supply of pulverized coal to the furnace will not exceed the capacity of the furnace. Soot blowers should be installed in settings where pulverized coal is used.

TABLE IV. TEST OF A PULVERIZED-FUEL-BURNING STATIONARY BOILER

Make of boiler			Edge Moor
Rated hp			468
Heating surface, sq.ft.			4685
Duration of test			24 hours
	Maximum	Minimum	Average
Temperature of boiler room, deg. F.	99.0	85.0	93.3
Temperature of feed water, deg. F.	168.0	135.0	157.2
Temperature of steam, deg. F.	477.0	427.0	448.7
Barometer, in. of mercury	29.35	29.20	29.25
Temperature of flue gases, deg. F.	515.0	455.0	495.3
Average boiler pressure, lb.			167.0
Temperature of steam, deg. F.			373.8
Superheat, deg. F.			74.9
Factor of evaporation			1.1502
Water evaporated from and at 212 deg. F. per lb. of coal, lb.			9.47
	Maximum	Minimum	Average
Carbon dioxide (CO_2), per cent.	15.4	12.2	13.85
Oxygen (O), per cent.	5.6	3.2	4.38
Carbon monoxide (CO)			None
Fuel used			Bituminous screenings

Fuel Analysis	No. 1	No. 2	No. 3	Average
Amount of coal represented by each sample, lb.	19,775.0	20,000.0	8,000.0	.....
Per cent. of total	41.3	41.1	16.9	.....
Moisture, per cent.	10.3	11.0	9.7	10.49
Volatile, per cent.	33.81	36.96	38.77	35.96
Fixed carbon, per cent.	50.43	49.13	48.29	49.53
Ash, per cent.	14.36	13.91	12.94	13.93
Sulphur, per cent.	1.90	2.06	2.12	2.04
B.t.u., as received	10,600.0	10,763.0	11,263.0	10,779
B.t.u. dry	11,817.0	12,093.0	12,473.0	12,045
Flues blown during test				5 times
Horsepower				546.2
Per cent. of rating				116.7
Boiler efficiency, per cent.				85.22
Memoranda—Fuel-preparation deduction:*				
Coal used in drier, lb.				1,140
Motor operation, kw.-hr.				449.3
Coal equivalent at 3 lb. per kw.-hr., lb.				1,348
Total deduction, lb.				2,488
Resulting net efficiency, per cent				81.1

*No deduction made for stand-by losses in drier.

The equipment for using pulverized coal is standard for any grade of coal so far as handling, preparing and delivering to the furnace is concerned. Only a slight change is necessary in the furnace to take care of coals of very low volatile content, such as anthracite, culm and coke breeze, and increased drying capacity is desirable when lignite coal is used. With stokers this is not the case as the varying quality of coals require different type stokers to obtain highest efficiency.

Saving in Labor Cost

The labor required to operate a pulverized-coal installation may be of higher class, but the number of men required will be less in the larger installations than that required for a stoker installation, thereby affecting a saving in the labor charge in favor of pulverized coal.

Table IV is a report of a test made on a 468-hp.

boiler using pulverized coal as fuel. The boiler is a three-pass water-tube boiler, with superheater.

At this same plant are other boilers fired by one of the most efficient types of underfeed stokers. A comparison is made between results of foregoing test and tests made on the stoker-fired boilers.

Pulverized Coal vs. Mechanical Stokers

Under this heading fuel-preparation costs will first be considered. In the case of powdered coal this can be classed under three general divisions:

The cost of crushing the coal. This expense is the same for pulverized-coal equipment as for stokers.

The cost of drying and pulverizing the coal. Although no cost records are available at present, it is estimated that 32c. per ton will cover this preparation cost on a 200-ton-per-24-hr. plant using bituminous coal containing about 12 per cent. moisture.

The maintenance costs of the drying and pulverizing plant. This unit has not been determined from actual experience; however, it is estimated that 3c. per ton will cover the maintenance. In stoker practice the maintenance cost per ton of fuel fired is close to 5c. per ton.

Summarizing the foregoing facts, it is evident that with fuel at $5 per ton the gross efficiency shown by the pulverized-fuel boilers will have to exceed that shown by the mechanical-stoker-fired boilers by 6 per cent. to offset coal-preparation costs.

Discussion by Albert A. Cary

In the early part of 1831 an English patent was issued to J. S. Daws for a process for burning powdered coal, and this was rapidly followed by a large number of patents relating to this subject in England, in the United States, in Germany and elsewhere, and descriptions of the varied use and application of such equipments will be found scattered through many of the old engineering publications.

In April, 1881, nearly 40 years ago, a United States patent was issued to C. H. Palmer, describing the means for feeding fine coal to a locomotive boiler with an air blast. In 1870, Whelpley & Storer began to take out a series of patents for using pulverized coal in reverberatory metallurgical furnaces. In 1876, an elaborate series of tests were conducted by the United States Steam Engineering Bureau of the Navy Department under the direction of B. W. Isherwood, using the Whelpley & Storer pulverized-coal system applied to a steam boiler.

During the last decade (or even for a much shorter period) there have been many powdered-coal installations made for various applications, which have been followed by rejections, or in other cases they will be found giving poor satisfaction and failing to realize the enthusiastic claims that led to their installation.

In the light of my experience and with the evidence presented by many satisfactory equipments now in operation, I am an unqualified advocate of the use of such fuel. But I certainly limit my indorsement to applications where a desirable grade of fuel is available, where proper preparation of the fuel and proper furnace conditions can be obtained and where other methods for burning the available fuel are inferior to accomplish the desired heating.

Recent developments have done much to overcome difficulties formerly experienced with the use of pulverized coal in stationary boiler plants, and consequently we find, today, a number of such installations in use, some of them showing desirable economy and producing a material increase in the steaming capacity of the boilers. A few such installations have been made in central power stations where the result of their experience is being watched with much interest.

With the close proximity of the heating surfaces of the boiler, care must be taken to prevent the unconsumed coal from coming in contact with such chilling surfaces. This requirement demands the use of a properly constructed extension furnace in which the complete combustion of the coal should be accomplished and in which proper handling of the fine ash (and its resulting slag) should be cared for.

All that applies to extension furnaces applied to short reverberatory furnaces applies with equal force to steam-boiler furnaces.

The cost of a milling plant for properly drying and pulverizing the coal, as well as the space required for its installation, often proves an obstacle to the installation of such equipment.

With the intense heat generated in burning pulverized coal, much trouble has been experienced in improperly designed boiler furnaces owing to the rapid melting down of the refractory linings, which linings may also be subjected to the scouring or cutting action of impinging ash.

The type of furnace used has much to do with the quality of coal required to obtain the best results, but generally speaking, such coal as Mr. Harrison describes, averaging between 30 and 40 per cent. in volatile and between 40 and 50 per cent. in fixed carbon and low in percentage of ash, will give excellent results.

Generally speaking, the presence of a considerable percentage of volatile combustible matter is most important as may be appreciated when we consider the progress of combustion taking place with this class of fuel.

Pulverized coal *must* be burned while suspended in the current of air which accompanies it into the furnace.

As the finely divided coal enters the highly heated furnace, any moisture each minute particle contains is first driven out, and if this is excessive, it will form a steam cloud around the particle and suppress its further rapid combustion, thus defeating to a greater or less extent, the purpose for which the coal was prepared. One of the necessities for supplying the furnace with very dry pulverized coal is thus appreciated.

With little or no moisture present, the next effect of the very high surrounding temperature in the furnace is to almost instantly distill off the volatile matter occluded in the coal as this gas is liberated at a comparatively low temperature and thus, with properly designed furnace and burner, the dust cloud entering the combustion chamber suddenly becomes thoroughly saturated with a highly inflammable gas, mixed with an ample supply of air. Under these conditions the gas is raised with great rapidity to its ignition temperature and the flame produced is propagated with intense speed throughout the atmosphere of fuel and air entering the furnace; all of which is simultaneously subjected to the same action.

With the intense degree of heat thus generated, not only is the temperature of the furnace maintained to stimulate further combustion, but the particles of fixed carbon (or flecks of coke) left behind, after the volatile

gases have been driven out of the coal, have their temperature raised with great rapidity to their temperature of ignition, and so are most speedily burned, leaving behind the noncombustible matter to be more or less effectively taken care of in a properly designed furnace, or to give great trouble in furnaces where its importance has been ignored.

The effect of the decreased surface in proportion to the mass results in a very great retardation of the combustion of the larger particles, as is very plainly shown in the photographic study of the combustion of coal dust in Bulletin No. 102 of the Bureau of Mines, entitled, "The Inflammability of Illinois Coal Dusts," on Plate IV.B and Plate V.B.

Uniformity in the size of pulverized particles is also very desirable. When coal averaging from 30 to 40 per cent. of volatile matter is pulverized so that over 90 per cent. will pass through a 200-mesh screen, the finer coal accompanying it does not seem to materially affect its even rapid burning effect in general furnace practice, and further, as Mr. Harrison has stated on Page 13 of his paper, with this very fine pulverization, which insures rapid and high temperature combustion, the sulphur in the coal burns rapidly to SO_2 gas, which passes to the stack without affecting the product of the reverberatory furnace.

When a coal running high in fixed carbon is used as pulverized fuel, we have a different and less desirable set of furnace conditions.

Lacking the production of an ample supply of volatile combustible gases, also lacking the heating effect which the burning of these gases produce, to hasten the combustion of the associated fixed carbon, we must necessarily maintain a higher furnace temperature to ignite this fuel, and to obtain the best possible result the coal should be ground finer.

There is a considerable range in cost of equipments as furnished by different concerns, and the figures presented in this table appear low for the better class of equipment. Again, should you decide to grind the coal very fine to obtain maximum furnace results, the output capacity of the pulverizer would be materially reduced below that needed for coarser pulverization and more or larger mills would be needed.

Whereas, Mr. Harrison's total cost for pulverizing 80 and 90 tons of coal per day agrees pretty well with the cost estimate given in this table, his cost for producing 100 tons per day runs 21 per cent. higher than the figure shown in the table.

In looking over the log of the boiler test given in Mr. Harrison's paper, I notice what appear to be a few discrepancies, but lacking full and complete data, I have been unable to check them.

Taking his analysis of furnace gases, he gives the maximum result obtained as 15.4 per cent. of CO_2 and 5.6 per cent. of O with no CO. This is consistent and possible.

He then gives his minimum result obtained as 12.2 per cent. of CO_2 and 3.2 per cent. of O with no CO; the sum of these gases giving 15.4 per cent. with 84.6 per cent. of N by difference.

There is evidently some discrepancy here, as I do not see how it is possible to burn such a coal as he indicates so as to obtain such an analysis.

The figures also given by him in his average gas analysis are not consistent. The percentage of boiler efficiency given in this table, as 85.22 per cent. seems on the whole entirely inconsistent, and I cannot find sufficient indication, contained in the other data submitted, to assure me that the total losses in the performance of this test amounted to only 14.78 per cent.

Pulverized Coal for Stationary Boilers*

By FREDERICK A. SCHEFFLER and H. G. BARNHURST

It is the purpose of this paper to present those facts which the authors believe indicate the coming general adoption of pulverized coal as a fuel for boilers. Since stoker firing is the most efficient method when solid fuels are used, a comparison of stoker and pulverized-fuel plants is given, with particular reference to reliability, cost, adaptability and efficiency.

THE ULTIMATE adoption of a new method depends entirely on its over-all commercial efficiency. In the generation of power, over-all efficiency may be considered as composed of the following factors: reliability, cost and adaptability.

Let us compare the reliability of a pulverized-coal installation with that of stokers. This factor depends on two items—apparatus for preparing and presenting the fuel for combustion, and continuity of operation of the furnace itself. In a stoker installation the first of these includes the stoker itself. Neglecting the inherent defects of any system that presents a metal mechanism to the action of high temperatures, it may be admitted readily that the stoker sysem is satisfactorily reliable, with respect to its apparatus, for preparing and presenting the coal for combustion.

The corresponding mechanisms for pulverized fuel are equally reliable. This fact is proved by their widespread use for years in the cement industry and more recently in an ever-increasing variety of industries. These mechanisims are not innovations, but are the result of years of development under operating conditions. Proper design of equipment by engineers of standing who are specialists in this line has made negligible the danger of dust explosions.

Cost per B.T.U. Delivered to Boiler

The second condition for reliability is the continuity of operation of the furnace. Here again we find an apparent balance between stoker and pulverized-fuel installations during operation. The advantage lies with pulverized fuel, however, for several reasons. The mechanism is altogether outside the furnace, hence cleaning and adjustment and the making of the few repairs required need not interrupt the operation of the boiler. In case of sudden necessity the fire may be ignited and quickly brought to full intensity, or it may be extinguished almost instantly.

*An abstract of a paper presented at the Spring Meeting of the American Society of Mechanical Engineers, Detroit, Mich., June, 1919.

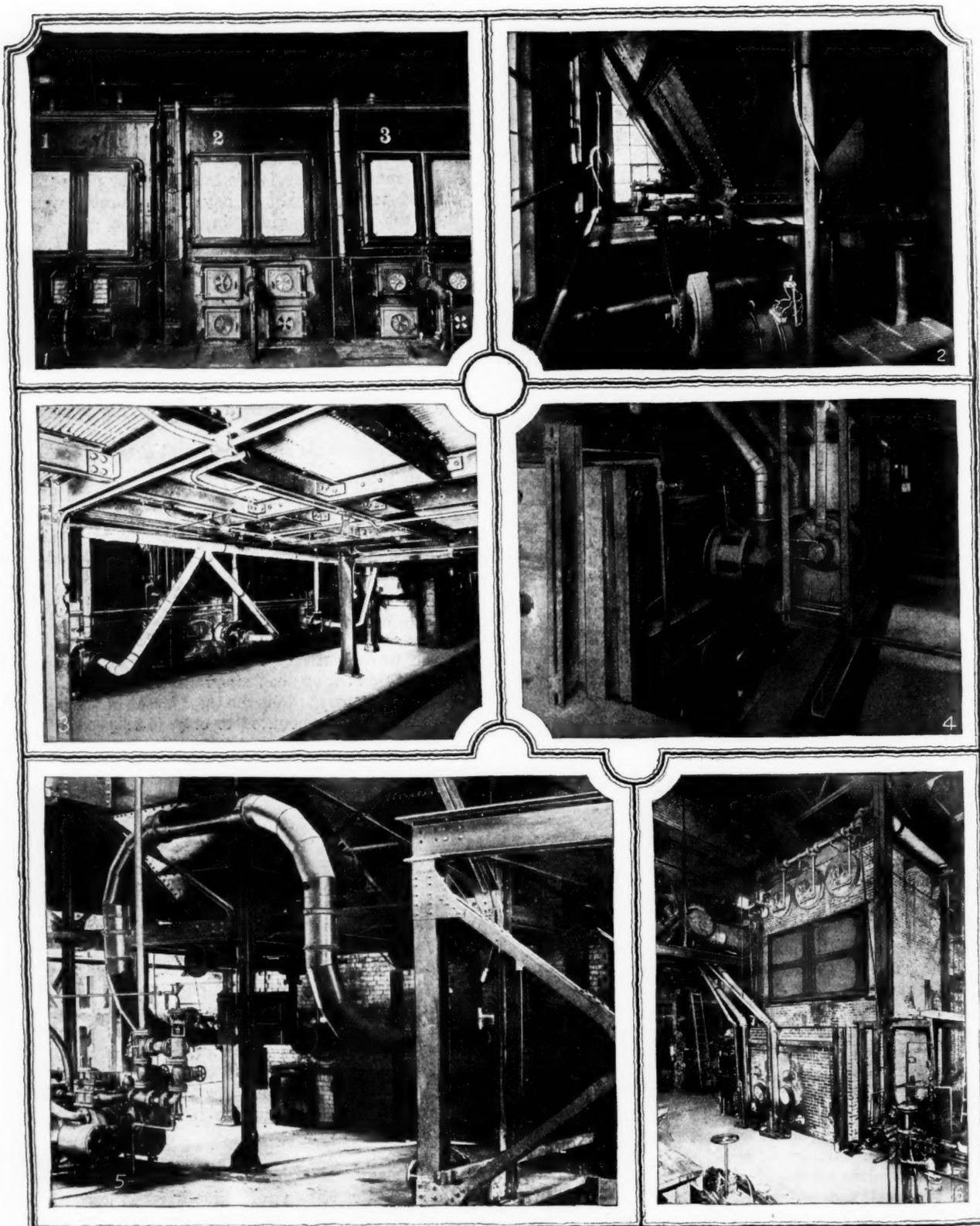


Fig. 1—Boilers at Broadway High School, Seattle, Wash. Fig. 2—Feeder for two 50-hp. Badenhausen Boilers, British Columbia Sugar Refinery Co., Vancouver, B. C. Fig. 3—Three 150-hp. Return-tubular Boilers, British Columbia Sugar Refinery Co., Vancouver, B. C. Fig. 4—Burners for two 50-hp. Badenhausen Boilers, British Columbia Sugar Refinery Co., Vancouver, B. C. Fig. 5—Two 430-hp. Stirling Boilers, United Verde Extension Mining Co., Jerome, Ariz. Fig. 6—One 600-hp. Boiler, Western Avenue Station, Puget Sound Traction, Light and Power Company, Seattle, Wash.

The second factor, cost, refers to the cost per B.t.u. delivered to the boiler. The various items entering into this cost by the stoker system comprise power, repairs and maintenance, labor, interest on investment, depreciation, insurance and taxes. With pulverized-coal equipment the cost of fuel for the drier should be added to the preceding items. A moment's consideration will show that this item must be taken care of in the furnace of a stoker-fired boiler and that it is clearly cheaper to remove the excess moisture content from the coal in a drier, from which the gases leave at very low temperature, than in the furnace itself, where the evaporation of the moisture damps the fire, increases the content of inert gases and at the same time carries off an appreciable amount of heat.

Returning to the balanced cost items, it appears that these show a saving in favor of pulverized fuel in a large power plant and for the stoker in a small power plant. It should be noted that when central pulverizing plants are built, they will relieve small power plants of the necessity for maintaining pulverizing equipment and make pulverized fuel considerably cheaper than stoker-fed fuel, regardless of the size of installation.

The flexibility in the use of pulverized fuel is perfect, and the fire may be instantly adjusted to suit any condition of overload or lower load, including the cutting in and out of the boilers. The paramount importance of this feature and the utter impossibility of approaching it with stoker or grate firing is readily evident.

The Design of Furnaces for Pulverized Coal

The primary requisite for good results is to maintain low velocities in the furnace. The combustion is no less perfect with high velocities, but this will result in damage to the linings and in their erosion. A furnace cubical in shape usually gives the most satisfactory results.

The burners should inject the coal under low pressure and should permit of varying the density of the mixture in the burner itself. Their location and number will depend on the size of the boiler and rating required, and also may be varied to suit the grade of fuel. High boiler ratings such as are used in modern boiler practice can be obtained when desired, and such overratings should be predetermined and the furnace volume designed accordingly.

In Table I will be found an itemized statement of the costs of pulverizing coal. Table II gives a list of boiler installations using pulverized coal and Table III reports of preliminary tests made on some of the pulverized-fuel installations now in operation.

Cost of Pulverizing Coal

The cost of pulverizing the coal is of prime importance as low costs are essential for success and are achieved when the quantity used per day of 24 hours exceeds 100 tons. The cost of pulverizing is made up of a number of items as follows:

Power, repairs and maintenance, coal for drying, labor, interest, depreciation, insurance and taxes.

The power required in an up-to-date pulverized-coal plant is from 12 to 13 kw.-hr. per net ton of coal crushed, dried and pulverized. The additional power required for transferring the coal to the point of use and feeding it to the boilers will vary considerably, depending upon the distance transported, the size and number of the boilers and the conditions under which they operate. The power required for this latter purpose varies between 4 and 6 kw.-hr. per net ton, so that the total power for the entire process from the track and storage delivered to the boilers is 17 or 18 kw.-hr. per net ton. In the following paragraphs the cost of power has been assumed at ¾c. per kilowatt-hour.

The items of repairs, including material, labor and general upkeep of the plant or maintenance for the entire pulverizing plant and burning equipment will vary from 7 to 10c. per net ton of coal handled. The figures depend upon local conditions, and the size and general arrangement of the installation.

The item of coal for drying depends directly upon the percentage of moisture and upon the price of coal. Ordinarily, only from 1 to 1½ per cent. of the total amount of coal used is required for drying. Assuming coal to have an average of 7 per cent. moisture as received and the cost to be $2.50 per net ton, the cost per net ton of drying the coal will be 3c. At $5 per net ton the cost of the drier coal will be 6 cents.

The labor item is the greatest variable in connection with the pulverizing of coal, owing to the increased output that can be obtained in larger plants per man employed. It is also subject to local rates of wages. For example, assuming labor at 40c. per hour, a plant of 100 tons daily capacity, properly designed and equipped, will require approximately 34 labor hours to prepare the fuel and deliver it to the conveyors, whereas in a plant having a daily capacity of 1000 tons, approximately 115 labor hours are required. Therefore the labor cost would be 14c. per net ton in a 100-ton plant, only 4c. per net ton in a 1000-ton plant, and as low as 2½c. per net ton in a plant of 5000 tons daily capacity.

TABLE I. COST OF DELIVERING PULVERIZED FUEL TO BOILERS

	100-Ton Plant, Dollars per Net Ton	1000-Ton Plant, Dollars per Net Ton
Power at ¾c. per kw.-hr. and 17 kw.-hr. per net ton...	$0.1275	$0.1275
Labor at 40c. per hour	.14	.04
Drier coal at $5 per net ton delivered	.06	.06
Repairs	.07	.07
Total actual cost of pulverizing per net ton	$0.3975	$0.2975
Interest at 6 per cent	$0.105	$0.039
Depreciation	.12	.04
Taxes and insurance	.035	.013
Total cost per net ton	$0.6575	$0.3895

The interest item is based on 6 per cent. of the entire investment, and the cost of the pulverized-coal plant and burning equipment will of course vary considerably with the conditions under which the plant itself is installed. Roughly speaking, however, the actual investment will vary from $12.80 per kw. output in a 5000-kw. plant down to $4.80 per kw. in a 50,000-kw. plant and $4.12 in a 100,000-kw. plant (assuming a turbo-generator water rate of 16 lb. and continuous boiler and furnace efficiency of 75 per cent.).

All these figures in relation to cost are based on the present high prices. The investment required for a 5000-kw. plant using 100 tons of pulverized coal daily is approximately $64,000 and for a 50,000-kw. plant using 1000 tons of pulverized coal daily, approximately $240,000, so that, on a basis of 6 per cent. and allowing for 365 days' continuous operation, the interest item will vary from 10½c. per net ton in a 100-ton plant down to 3.9c. per ton in a 1000-ton plant.

Depreciation in a coal-pulverizing plant is usually calculated as follows The life of the building is considered as 40 years, of the coal driers as 15 years and of the balance of the equipment as 20 years. With a 100-ton pulverized-coal plant and burning equipment the depreciation item will be approximately 12c. per net ton.

and in a plant of 1000 tons daily capacity it will be approximately 4c. per net ton.

Taxes and insurance are based on 2 per cent. of the entire investment and for a 100-ton plant this item is approximately 3½c. per ton and for a 1000-ton plant, $1\frac{3}{10}$c. per ton. Summarizing the foregoing results shows that the total cost of pulverizing and delivering pulverized coal to boilers is approximately as in Table I. The cost of the pulverizing equipment complete compares favorably with the stoker equipment when everything, such as coal- and ash-conveying machines, etc., is taken into consideration, and in large plants it is considerably less.

TABLE II. BOILER INSTALLATIONS USING PULVERIZED COAL

Date of Installation	Name of Company	Location	No. of Boilers	Horsepower Rating and Make of Boilers	Furnace Design, Per Cent. of Rating	Coal Used
Aug., 1916	M. K. & T. R.R.	Parsons, Kan.	8	250 O'Brien	125–150	McAllister Cherokee slack, Kan., semi-anthracite, Texas lignites San Bois coal, Oklahoma
Nov., 1916	American Locomotive Co.	Schenectady, N. Y.	1	300 Franklin	150	
June, 1918	U. S. Verde Extension Mining Co.	Verde, Ariz.	2	439 Stirling	150	Gallup and semi-lignite
Feb., 1918	Ash Grove Lime and Cement Co.	Chanute, Kan.	1	371 Heine	150	Various grades of Kansas coals
June, 1918	Garfield Smelting Co.	Garfield, Utah	2	371 Stirling	150	Wyoming lignite, Wyopa, Wyoming lignite. Keystone, Utah, bituminous from various mines
Nov., 1918	Puget Sound Light and Power Co.	Seattle, Wash.	10	4–300 B. & W. 2–600 B. & W. 3–400 B. & W. 1–500 B. & W.	150	Renton buckwheat, Washington bituminous lignite and sub-bituminous
Nov. 1917	Sizer Forge Co.*	Buffalo, N. Y.	5	250 Rust	125	Pittsburgh and Pennsylvania
Mar., 1919	British Columbia Sugar Refinery Co.	Vancouver, B. C.	13	2–504 Badenhausen 2–250 B. & W. 9–110 HRT	150	Vancouver, B. C., bituminous and lignite
July, 1918	Milwaukee Electric Railway & Lighting Co.	Milwaukee, Wis.	5	468 Edge Moor	150	Indiana and Illinois bituminous, Pittsburgh and Youghiogheny
Mar., 1919	Allegheny Steel Co.	Allegheny, Penn.	1	333 Wickes	...	Pittsburgh coals
June, 1919	Inland Steel Co.	Chicago Heights, Ill.	1	250 Heine	150	Illinois bituminous
June, 1918	Pacific Coast Coal Co.	Seattle, Wash.	10	150 HRT	...	Renton buckwheat
			8	100 HRT	...	Washington bituminous, lignite and sub-bituminous
Nov., 1918	Susquehanna Collieries Co.	Lykens, Penn.	1	250 B. & W.	200	All grades of anthracite washery culm, mine dirt, No. 3 buckwheat, Lykens slush, Lytle slush
June, 1919	Lytle Coal Co.	Lytle, Penn.	6	333 B. & W.	200	All grades of anthracite, washery culm, Lytle slush
May, 1919	Garfield Smelting Co. (2d installation)	Garfield, Utah	4	371 Stirling	150	Wyoming lignite, Wyopa, Wyoming lignite, Keystone, Utah, bituminous from various mines
Sept., 1918	L. S. Smith Bldg.	Seattle, Wash.	2	1–300 B. & W. 1–200 B. & W.	...	Obtain and use coal from Pacific Coast Coal Co.
Sept., 1918	Crystal Natatorium	Seattle, Wash.	2	72 x 18 HRT	...	Obtain and use coal from Pacific Coast Coal Co.
Sept., 1918	Crystal Natatorium	Seattle, Wash.	2	72 x 18 HRT	...	Obtain and use coal from Pacific Coast Coal Co.
Sept., 1918	Pacific Coast Coal Co.	Seattle, Wash.	12	2–250 Wickes 2–125 Ames (72 x 16) 6–125 Chandler & Taylor 2–125 Casey-Hedges	...	Obtain and use coal from Pacific Coast Coal Co.

*Also use some waste heat from pulverized-coal-fired furnaces.

TABLE III. REPORT OF PRELIMINARY TESTS MADE ON PULVERIZED-FUEL PLANTS

Date of Test	Location of Plant	Duration, Hours	Coal Used	Efficiency Maintained, Per Cent.	B.t.u. per Lb. of Coal as Fired	Ash, Per Cent.	Rating Per Cent.
Apr. 16, 1917	Seattle, Wash.	14.5	Renton buckwheat	77.0	10,000	11.60	122.0
Dec. 4, 1917	Chanute, Kan.	5.0	Kansas bituminous	72.0	11,996	17.7	125.0
Dec. 12, 1917	Chanute, Kan.	5.0	Kansas bituminous	83.94	12,500	18.25	125.0
Jan. 28, 1918	Chanute, Kan.	(25 days)	Kansas bituminous	78.1	11,435	.....	100.0
Apr. 26, 1918	Parsons, Kan.	6.0	Kansas bituminous	80.3	12,900	17.49	.....
Apr. 28, 1918	Parsons, Kan.	6.0	Kansas bituminous	80.9	12,289	17.49	130.8
June 14, 1918	Milwaukee, Wis.	12.0	Illinois and Indiana screenings	83.3	10,897	15.89	117.7
Nov. 5, 1918	Lykens, Penn.	10.0	Lykens No. 3 buckwheat anthracite	84.2	12,530	16.92	135.0
Nov. 15, 1918	Lykens, Penn.	5.0	Lykens slush buckwheat anthracite	81.2	13,653	11.09	142.0
Nov. 22, 1918	Lykens, Penn.	5.0	Lykens slush buckwheat anthracite	85.0	12,753	18.04	146.0
Nov. 23, 1918	Lykens, Penn.	5.0	No. 3 buckhweat anthracite	72.7	12,530	16.91	115.0
Dec. 2, 1918	Lykens, Penn.	5.0	Lytle slush anthracite	75.3	15,420	23.92	188.0
Feb. 1, 1919	Seattle, Wash.	24.0	Issaquah screenings	78.95	11,660	14.31	126.0
Feb. 2, 1919	Lykens, Penn.	4.0	No. 3 buckwheat anthracite	78.9	13,067	14.02	177.0
Apr. 7, 1919	Vancouver, B. C.	4.0	Nanaimo slack	83.3	9,364	28.4	125.0
Apr. 17, 1919	Vancouver, B. C.	5.0	Nanaimo slack	77.1	10,050	24.3	160.0
Feb. 3, 1919	Lykens, Penn.	5.5	No. 3 buckwheat anthracite	78.9	12,530	14.00	.....
Sept. 24, 1918	Verde, Ariz.	(6 days)	Gallup, New Mexico	79.5	10,680	14.31	155.0

Discussion by Thomas A. Marsh

The general proposition of taking raw coal with all its byproducts and preparing it to the most expensive size (pulverized) and then burning still raw coal and losing the byproducts appears to be a move much in the wrong direction. Pulverized coal has a field, no doubt; for instance, such lignites as cannot be burned on stokers. This field is limited, however, for chain grates are now developed to burn lignites containing 30 to 35 per cent. moisture, which embraces practically all but those of the North Dakota field.

It is evident from this paper that even to make a comparison for steam boilers it is necessary to represent pulverized fuel at its best, to hint at not a drawback or trouble, to submit tests of four or five hours' duration, and evidently not made under the A. S. M. E. code, to favor this equipment in figures in every way and to contrast stokers of the most expensive type to operate as to power to drive and as to power for fans. If it is necessary to resort to such extremities to make a comparable showing for pulverized fuel, it cannot be said that it is on a competitive basis with modern automatic stokers and furnaces.

Speaking of reliability, the authors state unqualifiedly that the mechanisms for pulverizing fuel are equally reliable with those for crushing coal for stokers. The extra equipment necessary for this exceedingly elaborate preparation of the fuel is another link, and a high speed one at that, to the mechanism. No engineer will agree that the combination of a crusher system and a pulverizing system is equally reliable to a crusher alone.

The writer understands that cement plants are usually equipped with duplicate pulverizing systems.

It is mentioned that all grades of coal can be used. There are stokers which have limitations only on anthracite or coke braize, and in this connection the question arises as to whether a pulverized-coal furnace and burner designed for, say, bituminous 35 per cent. volatile will burn anthracite or coke braize. I ask this because in one other technical society it is a matter of recent record that for burning low-grade anthracite or coke braize in pulverized form, reversal of the flame is necessary, a firing method not suitable for the richer bituminous coals. It was also brought out that with coke braize or anthracite culm, the fire was unresponsive and the load had to vary to suit the fire rather than the fire to suit the boiler load. What occurs when a rich, high-grade fuel is used in a furnace and burner designed for low-grade fuels? It is mentioned that the primary feature is the possibility of burning all grades of fuel without affecting the efficiency of the furnace. For this to be true, it is necessary to burn the 50 per

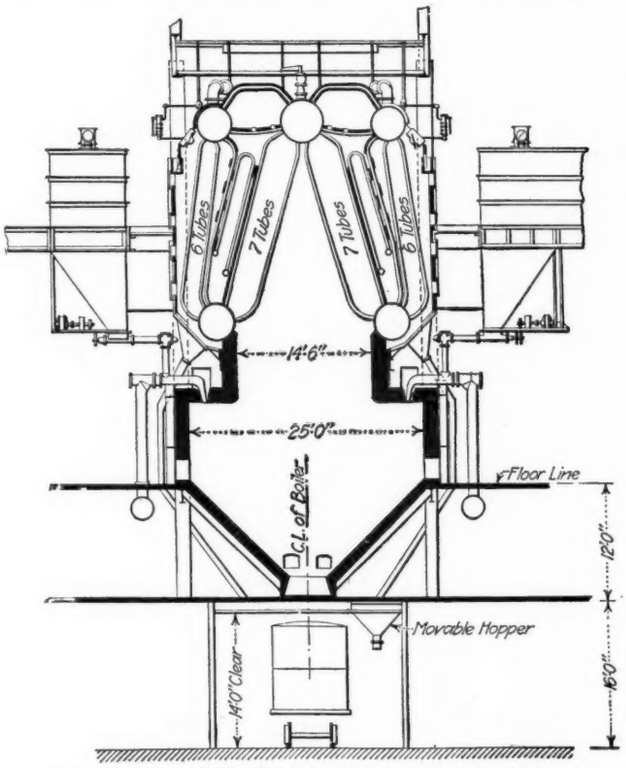


FIG. 1. DETROIT EDISON TYPE 2400-HP. BOILER ARRANGED TO BURN PULVERIZED COAL AT 200 PER CENT. RATING

cent. ash coal with no more excess air than the 3 per cent. ash coal and suffer no more ashpit loss in the former case than in the latter. The writer therefore specifically asks if the 50 per cent. ash coal requires in practice no more air than the 3 per cent. ash coal. When 50 per cent. ash coal is used, the sensible heat of this amount of refuse leaving the furnace chamber is in itself an item that will affect the efficiency of the furnace. Now, therefore, can efficiencies be independent of these items? The tests show wide variation in efficiencies. What causes these wide variations?

Chain grates are, and have been for years, burning coals containing 35 per cent. ash and producing some excellent results. It is to be regretted that the authors in making this statement regarding high-ash fuels did not submit figures of tests with anything over 28.4 per cent. ash, a comparatively low figure as compared with chain-grate practice with Western fuels.

As to flexibility with pulverized coal, the writer has seen plants where the furnace became unresponsive when forced. There is certainly no evidence in the paper to prove or even indicate that the pulverized-fuel burner is quickly responsive over a wide range of loads; in fact, the evidence is much to the contrary, for of all the tests referred to, the maximum overload indicated is 188 per cent., which is not considered a high overload in modern practice. The writer would in-

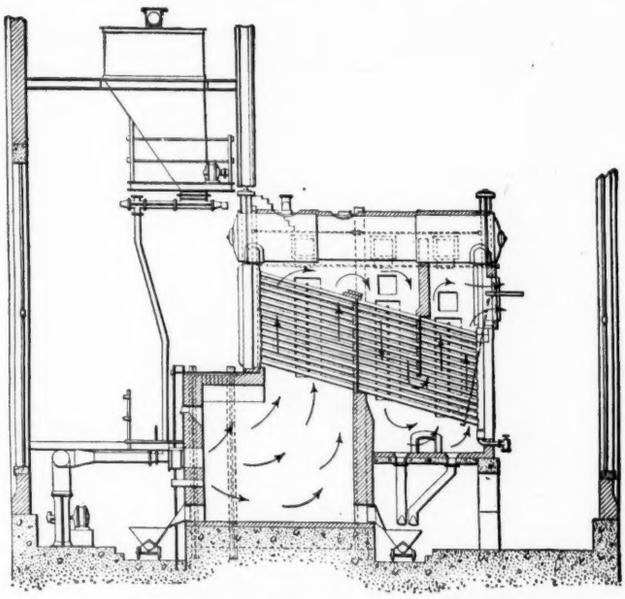


FIG. 2. BABCOCK & WILCOX BOILER ARRANGED TO BE FIRED WITH PULVERIZED COAL

quire if in the test at Seattle the heating value of the coal was determined by a calorimeter, or was it assumed? The even figure of 10,000 simply suggests an assumption.

What great difference brought about the marked increase in efficiency between the Dec. 4 and Dec. 12, 1917, tests at Chanute, Kan.? This wide difference is inconsistent with the statement of uniform efficiencies, regardless of operatives, coal or other items.

The authors have selected for comparison those types of stokers with which it is most difficult to get high operating efficiencies, whereas if the comparison were made with completely automatic stokers the statement made about the operating advantage becomes void.

All costs of pulverizing coal are based on only 7 per cent. moisture, and yet many of the fuels mentioned in the tests contain more than 7 per cent. Comparatively few fuels have as low as 7 per cent. moisture, particularly west of Pittsburgh. The figures run from 10 to 40 per cent. in the western section of the country, 15 per cent. predominating. The writer suggests that the drying coal cost be doubled.

As mentioned earlier, the pulverizing equipment should be duplicated to prevent shutdowns, which would of course raise the equipment's interest charge.

Now as to some of the items not mentioned in the author's paper.

Fine Ash: The writer understands that from 60 to 80 per cent. of the ash carries over to lodge in the tubes and combustion chambers, going out of the chimney

to scatter over the surrounding country. This may by comparison not be objectionable in a cement mill or in some of the localities mentioned in the list of installations, but it is evident that if the Commonwealth Edison Co., for example, was to scatter fine ash from the 5000 or more tons of coal it burns daily, say 600 to 800 tons of ash (from one company) over Chicago, it would create a condition compared with which the worst smoke fog would seem like a paradise.

Slag in Tubes: Some installations have encountered trouble due to the fine ash slagging in the tubes. The writer would inquire how prevalent this is, how it is overcome or prevented and what influence high boiler ratings seem to exert on this.

Slag in Ashpits: The refuse from pulverized-fuel firing contains some combustible. It has been reported that the slag containing this combustible causes damage to ashpits. Is this a serious item of maintenance? It is reported that pulverized fuel if stored will pack and become difficult to handle. Where the container is jarred or vibrated, this action is reported to increase. How serious is this action? Does it interfere with the use of stored powdered coal? Does it preclude its use on shipboard?

Pulverized Coal, Coal Storage, and the Schultz System of Burning Fine Coal*

REGARDING pulverized coal the most important information in the committee's report was that one pulverized coal machinery company was now furnishing equipment for two 1200-hp. boilers in a central station. The results will be closely watched and reported upon. As for coal storage and burning of fine coal, the discussion brought out more things of interest than the report brought out.

Discussion

Chairman McClelland, Technical and Hydraulic Section—In Seattle a company is supplying powdered fuel to four or five installations in the city, apartment houses and office buildings, hotels, etc. They ship it in closed tank cars and deliver it in closed tank wagons, and it runs from the wagon by gravity into the customer's receptacles. But the difficulty comes in the grinding and powdering. The operation is not standardized. There are several types of materials and grinders; and it is here that one considering the use of such fuel should be careful. It is where the large part of the investment lies. If we can get some of these large coal companies to do the powdering and deliver the coal in that form, that will be a splendid thing for the isolated plants.

The charge for the coal in Seattle, pulverized and delivered at $7 a ton, is about $1.50 a ton for preparation.

Chairman Carle—The pulverized-fuel situation is a combination of pulverizing good coal and bad coal together. To extend its use to apartment houses, I understand a company has been organized in New York, which will deliver it in containers. The serious trouble is that nobody furnishes all of the apparatus and all of the engineering, although some are starting to. This situation is holding up the development. The builders must take up the whole situation—be responsible for the apparatus and all connected with it.

The user of powdered coal in a large Milwaukee power plant told me that since last May they have made observations on dust from pulverized-fuel furnaces and cannot find deposit of this dust on the Milwaukee roofs. They say it goes from six to ten miles away and then comes down in a moist form, as dew or rain comes down. The refuse or ash from pulverized fuel will stay in the air, as cigar smoke does, before settling.

I. E. Moultrop—I would like the chairman or Mr. W. L. Abbott to state something to the audience in relation to the Schultz method of burning coal.

W. L. Abbott, Chief Engineer, Commonwealth Edison Co., Chicago, Ill.—The device referred to has been installed under a boiler at the University of Purdue. It has some original principles; I saw it once some months ago and it was working fine. I organized a party of half a dozen later on to go and look at it, and found it working badly.

I have confidence in it. It is a device to burn ground coal rather than pulverized coal, and it consists of a circular furnace into which the ground coal is projected tangentially and burns while whirling in this circular box. Air is admitted through a hole in the center of the bottom, and the gases escape at the top through a hole in the center. Due to the whirling motion, the coal runs around on the interior circular surface, and burns while whirling. In that way the dust does not escape with the gases, which has to go through the center. In whirling around the coal is gasified and there is opportunity for it to burn in the secondary furnace above this retort where it is gasified. The ash from the retort is supposed to trickle down like molasses candy, and to solidify before it strikes the ashpit. It forms a pyramid of molten beads which cool off.

The largest permissible size of coal, according to the inventor, is about what would pass through a ½-in. round hole, which is far from the 200-mesh to grind when used in the ordinary pulverized-coal burner. It is not necessary to dry the coal before grinding. I have great hopes for the device, and I think that it may be so arranged by perhaps using a little larger size of coal than now contemplated, and get a supply for it by merely passing the screenings over a plate with, say, $\frac{3}{16}$-in. round holes. If that could be done it would greatly simplify the so-called pulverized-coal problem. The furnace was about 3 ft. internal diameter and would burn, say, 3000 lb. of coal an hour.

The Chairman—It was under a 250-hp. boiler and gave 150 per cent. rating at about 81 per cent. boiler efficiency.

W. L. Abbott—Professor Young, of Purdue University, has made tests on it which will be published soon. He reports a remarkable efficiency. That is, above 70 per cent., which is very high for our ordinary Illinois coal; a high ash is no deterrent to the system, as it has no ordinary furnace. The ash goes in with the coal and eliminates itself by melting and running out.

*From report of the Prime Movers Committee, National Electric Light Association, and discussion at convention.

Lockett Flat-Flame Oil Burner

When using the grades of crude oil having a heavy residuum, it is necessary to have a burner adapted to handle that class of fuel. Essential features of a good oil burner are simplicity, easily and cheaply renewable parts, economy in the use of steam for atomizing and the production of a flame that will make good combustion and high boiler efficiency possible.

To meet these requirements, A. M. Lockett & Co., Ltd., 533 Baronne St., New Orleans, La., have developed a burner of the fishtail-flame type. The only wearing part is the tip, which is made of steel, is cheaply renewable and has a long life. It can be cleaned easily by removing one plug. The oil pipe is straight and, if it becomes carbonized, can be cleaned without dismantling the burner, and it is provided with a steam bypass for blowing out the tip and strainer when shutting down. The burner is shown in Fig. 1.

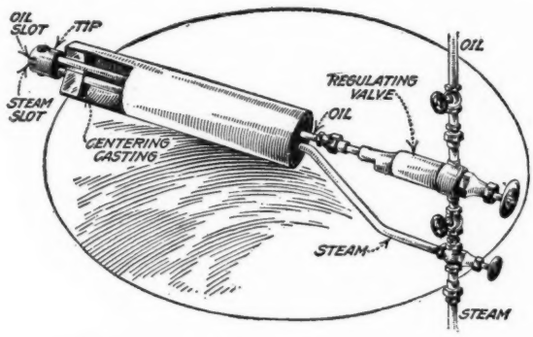


FIG. 1. FLAT-FLAME OIL BURNER

A regulating valve, used with the burner, is shown in section in Fig. 2. Oil is passed through a strainer in the regulating valve and therefore the oil feed is regulated after it has been strained. By discharging the oil through a slot instead of a ring, which gives an opening greater than the holes in the strainer, any dirt that passes through this strainer will pass through the opening. The strainer is easily removable for cleaning and can be quickly changed. The burner gives a flat fishtail flame, which means that it is possible to distribute the air for combustion uniformly over the whole area with a minimum of excess air.

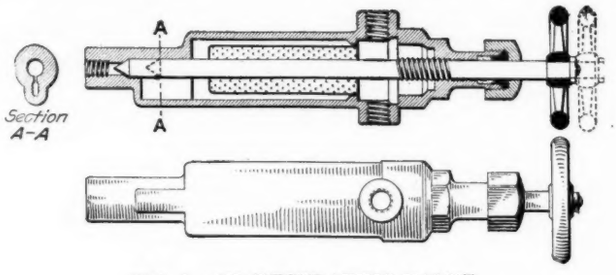


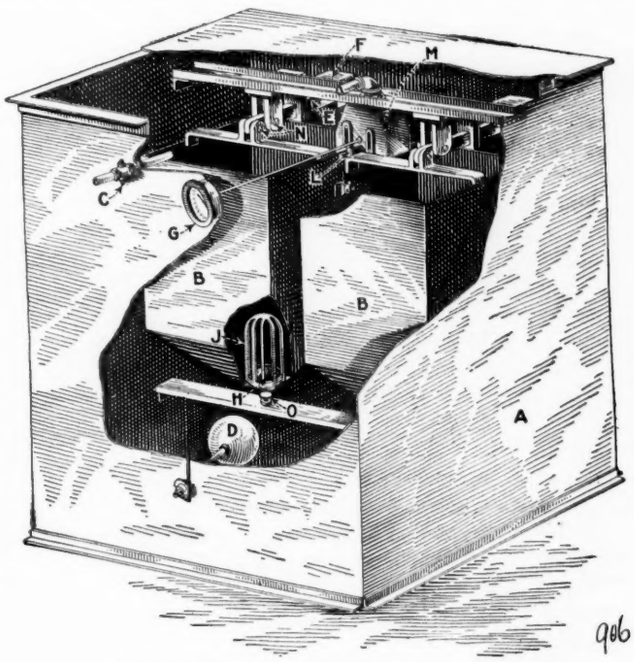
FIG. 2 OIL-REGULATING VALVE

Turner Automatic Water Weigher

The illustration shows an automatic water weigher that is manufactured by the Water Weighing Machine Co., Inc., Piqua, Ohio. *A* is the steel storage tank, *B* and *B* are cast-iron rectangular weighing buckets having hopper bottoms and open tops; *C* is the water inlet from the heater or other supply; *D* is a float and valve that maintains a constant water level in the storage tank; *E* and *F* are a scale beam and counterweight, the beam having knife-edge bearings at *N*.

In operation the water enters through the supply pipe *C* (shown broken) and flows into the bucket, which is held in its upward position by the weight *F*. If, say, the bucket is designed to weigh 100 lb. of water at each discharge, water will flow into this bucket until it contains 100 lb., when the weight of the bucket and water overcomes the counterweight *F*. The bucket then descends and as it does so it pulls down the lever *L* and this moves the valve *M*, causing the water to flow into the other bucket.

As the bucket descends it causes the round bronze valve *H* to strike the stop *O*. This valve has a bevel bronze seat. The ball valve *H* is held on its seat by the static pressure of the water. As it strikes the stop *O* the descent of the bucket causes the stop to push the valve off its seat, when its buoyancy causes it to rise to the top of the cage *J*. Water then pours out of the bucket through the valve opening, and after a small quantity has been discharged, the counterweight again slowly comes down to its normal position, but the water continues to discharge, and as soon as the level of the water reaches the valve, it then slowly descends and seats by gravity. When the other bucket fills, it operates in the same way, and as each bucket empties, it actuates the recorder *G*. An outlet at the bottom ordinarily connects with the pump suction.



SEMI-SECTIONAL VIEW OF WATER WEIGHER

This machine is easily calibrated; all that is necessary is to set the counterweight out on the end of the beam and pour into the bucket the exact weight of water it is designed to weigh at each discharge. This water must be weighed previously on scales known to be accurate. Then slowly move the counterweight along the beam until it just breaks the balance, and set the weight fast by a setscrew. The weigher is then ready for operation. The top is movable and can be removed and the operation observed at any time.

These machines are built in sizes from 6000 lb. to 48,000 lb. per hour maximum capacity, and larger sizes can readily be built.

Unusual Causes of Racing of Ammonia Compressors

By E. W. MILLER

In one case dry compressor valves, sticking at one extreme of travel, caused racing; in another a valve disk in the suction line worked loose, shutting off the flow of gas to the machine. Another compressor raced when the springs holding a false head in place broke, allowing the head to lift from its seat.

RECENTLY one of the ammonia compressors in our plant began to give considerable trouble because of racing. The machine was a 100-ton Boyle, having two vertical double-acting compressors with the engine vertical and set between the two compressors. Sometimes it would run along for a number of days without trouble, and then it would suddenly start off and race until the safety cams operated and shut down the engine unless someone happened to be near and managed to close the throttle. This happened a number of times; the governor, the whole machine in fact, was examined without finding the cause of the trouble.

Being somewhat at leisure one Sunday, I decided I would stick close to the outlaw during the day, particularly as it had shown indications in the morning of starting its regular capers. For the greater part of the day nothing happened. I was oiling the valve gear of the engine on the deck of the machine when trouble started. First the machine would speed up and then suddenly slow down until the valves on the engine failed to unhook. Then it would speed up again at a greater rate before it would swing to the other extreme and slow down. The throttle was closed enough to hold the speed down to a safe limit. I then had one of the assistants watch the throttle while I investigated the governor. This was in perfect condition; even the plates on the hooks and arms of the valve gear were in excellent order. These in many cases had caused similar troubles before, but not so in this case.

Sticky Valve Stems Cause Trouble

While I was examining the engine valve gear, an unusual slam in one of the compressors attracted attention. As near as could be judged it was a valve slamming down on its seat. At the same time the machine nearly stopped. With this as a clue I found a convenient box and settled down for a still watch for trouble. The wait was not long. The moment the machine started its capers gas could be heard whistling through one of the valves, and by a few smart raps on the cage the trouble was corrected before the man watching the engine could get to the throttle. Evidently, a valve was sticking.

When we removed the bonnets of the top valves of the compressor, it was found that the valve stems were dry and covered with a rather hard, sticky substance; this evidently had caused the valves on the top of the cylinders to stick at times and possibly on both compressors at the same time in some cases. It is presumable that when one of the valves stuck and unbalanced one of the compressors and the machine began to speed up, this intermittent action of the valves caused them to open more violently and move farther than normally, causing both to stick for short periods. If one or both valves let go at the same time and resumed normal operation while the machine was running at high speed and the governor at the top of its travel, it would slow the machine down so much that the safety cams would act and shut it down altogether.

The sticky substance was made up of oil and dirt, and when the discharge gas was very hot they baked on the valves and stems. It was apparent from the appearance of the stems that little oil reached the valves, as they were practically dry and had a high polish in places. There was reason for this as the oil supplied to the machine was applied to the stuffing-box lantern and of course all the oil that got into the compressor was that carried around the system and that which was carried into the cylinders with the piston rods. The oil that was drawn in by the piston rods went only to the bottom valves and that drawn in from the system went the same way, as it would naturally drag along the bottom of the pipes and go to the lower end of the machine where the branches to the suction valves were made

To remedy the trouble we first cleaned the valves and stems with gasoline and put them back in place. We then found two pressure oil cups that formerly had been used on the lanterns of the machine and drilled holes in the valve bonnets and connected the oil cups into them. By regulating the feed to about two drops per minute, the valves got plenty of oil and no further trouble was experienced.

Valve Disk in Suction Line Worked Loose

In another case one of the machines began to run away without any apparent reason. Everything would be going along nicely when, without warning, the machine would speed up at a rate that made it necessary to shut it down. This happened two or three times; the most thorough investigation failed to show anything wrong.

One day one of the engineers happened to be looking at the suction gage at the moment the machine went speeding. To his surprise the pressure went down to about 20 in. vacuum in a few moments. Here, evidently, was a clue to the trouble. Some place or somehow the line was shut off, and of course with no gas to pump there was no load on the machine, and it naturally got frisky. In the meantime one of the oilers had stopped the machine and started it again. The suction pressure had returned to normal a few moments after the machine stopped, and when the machine was again started it remained at normal, thus indicating that whatever the trouble was, it had disappeared when the machine was stopped.

Some of the crew wanted to pump down and investigate the machine from stem to stern, but one of the assistant engineers insisted that the trouble could not possibly be in the machine because machine trouble

would not cause the suction pressure to drop in the manner described. The force then directed their attention to the suction line. About 25 ft. back from the machine was a stop valve in the suction line, placed in horizontal position. Someone suggested that this valve might possibly stand investigation. So the line was pumped down and the bonnet of the valve removed. A glance was sufficient to disclose the cause of the trouble. The valve had been placed in the wrong position, and the flow through it had a tendency to close the valve against the seat. The disk had worked loose from the stem, and as the valve was of the globe type and lying on its side with the stem extending out in a horizontal position, the disk had been dropped to such a position that with a sudden rush of gas through the valve it would swing against the seat and the pressure would hold it in place. As soon as the machine was shut down there was sufficient leakage past the valve to fill the line again, when the disk would drop back to its regular position. To prevent further possibility of trouble from this source, the valve was reversed so as to bring the flow of the gases against the bottom of the disk, which would tend to open instead of close the passage in case the disk should be dropped at some other time.

Compressor Raced When Springs Broke

In another case a 150-ton vertical York compressor developed a serious case of racing. It would run along well for a few minutes and then start to cut up capers for a few revolutions. As usual, we did everything possible to the governor and valve gear of the engine but without results. The next move was to look into the valves of the compressors. We found nothing wrong in the first compressor, but got no further than the removal of the cylinder head of the second before we located the trouble. Four of the heavy springs holding the false head in place had broken, allowing the head to lift from the seat. At this time it had evidently got caught while partly cocked to one side, with the result that it had failed to seat at all, and of course the gas rushed back into the cylinder as fast as the piston went down. This is most likely what happened before when the machine began to race. Anyway, after putting in new springs in place of the old ones we had no further trouble.

Performance Tests of Economizers

By B. M. Baxter

Although economizers have been in quite general use for a considerable number of years, there has been a marked increase in the size and number of installations in the last few years. This has been due to two or three causes. The increased price of coal, which emphasized the fuel-saving advantages of the economizer; the development of the forced-draft underfeed stoker, which has made possible driving boilers at much higher rates than formerly; and the use of higher steam pressures and the consequent increase in the minimum flue-gas temperature, due to the necessary difference between steam temperature and flue-gas temperature for an economical rate of transfer of heat from the gases to the water in the boiler.

This increased use of economizers makes necessary some standardized method for conducting and reporting economizer tests and economizer performance.

The important factors entering into the design of an economizer to fit any given set of conditions are the rate of heat transfer from the gases to the water and the draft loss and also, to some extent, the efficiency. The first of these determines the heating surface necessary for the desired results; the second, the arrangement of the heating surface and the amount of free area between the tubes necessary to be provided to avoid undue resistance to the flow of the gases, or, expressed in another way, loss of draft. The third also affects the performance through determining the percentage of the available heat of the gases which can be counted upon to be absorbed by the feed water.

It is known that the rate of heat transfer from the gases to the water is materially affected by the velocity of the gases through the economizer. Hence, for the most economical design it is essential that as high velocity of the gases be obtained as the conditions of the installation in question will permit, thus obtaining the maximum return on the investment in the economizer. However, the increase in gas velocity causes a great increase in the resistance to the flow of the gases, or draft loss. Many economizer installations in the past have been faulty through failure properly to anticipate the draft loss, and it is in connection with the calculation of draft loss that present knowledge of economizer performance is incomplete.

Calculation of Draft Loss

The necessity of well-established rules for the calculation of draft loss is particularly evident in connection with economizers designed for operation with natural draft, as the proper proportioning of the economizer to the chimney is an operation requiring great care. If the heat absorption of the economizer is greater than calculated, the draft created by the stack will be less; and if at the same time the draft loss through the economizer is materially greater than calculated, the furnace draft may easily be too low to operate the boilers at the rate needed. With induced draft a lower temperature of gases leaving the economizer than calculated is beneficial, as the gases are denser and can be moved at a lower fan speed. Also, in induced-draft fan design it is easy to provide for sufficient variation in draft requirements to take care of any probable error in the method of calculation of draft loss, but it is desirable to have better data than at present available in order to avoid the expense that is incidental to provision of this kind.

The adoption of a standard method of making and reporting economizer tests and the publication of such tests so made would soon afford sufficient data from which to prepare accurate formulas covering all phases of economizer performance. All things have a beginning, and it is with the hope of making a start toward the adoption of such a standard method that the following form is proposed:

Form for Reporting Economizer Tests

1. Date of test.
2. Type of economizer, parallel flow or staggered tube.
3. Length of tubes.
4. Number of tubes per section.
5. Number of sections.
6. Square feet of heating surface, builder's rating.
7. Square feet free area between tubes.
8. Duration of test in hours.
9. Total amount of water passed through economizer

10. Average rate of flow of water through economizer, pounds per hour.
11. Average temperature of water entering economizer, degrees F.
12. Average temperature of water leaving economizer, degrees F.
13. Average temperature rise of water in passing through economizer.
14. Average temperature of gases entering economizer, degrees F.
15. Average temperature of gases leaving economizer, degrees F.
16. Average analysis of gases: Carbon dioxide, per cent.; carbon monoxide, per cent.; excess oxygen, per cent.
17. Pounds of flue gas per hour passing through economizer.
18. Average velocity of gases through economizer.
19. Average draft at entrance to economizer.
20. Average draft at exit from economizer.
21. Average draft drop through economizer.
22. B.t.u. transmitted per hour per square foot of heating surface.
23. Mean temperature difference between gases and water.
24. B.t.u. transmitted per hour per square foot of heating surface per degree mean-temperature difference. (Coefficient of heat transfer.)
25. Specific heat of gases. (State whether assumed or calculated.)
26. Efficiency. (Ratio of heat absorbed by water to heat lost by gases.)
27. Draft loss per section.

The purpose of items 1 to 15 needs no explanation. The analysis of the flue gases is necessary in order to calculate the weight of flue gas passed through the economizer, and in addition to the flue-gas analysis it is necessary to record the amount of fuel burned under the boilers operating in connection with the economizer and, if possible, the carbon content of the fuel. If an ultimate analysis of the fuel is not available, a close approximation can be made, if the mine from which the coal is obtained is known, and by reference to analyses of the Bureau of Mines.

The figure for the B.t.u. transmitted is obtained readily from the temperature rise of the water, but the calculation of the heat lost by the gases involved either an assumption of the specific heat, which is usually considered as 0.24, or a calculation of the specific heat based on the proportions of carbon dioxide, carbon monoxide, oxygen and moisture.

The weight of the flue gas passing through the economizer is also determined from the gas analysis. This figure is desirable as it appears that there is a definite relationship between the weight of gas per foot of tube, the mean-temperature difference between gases and water and the coefficient of heat transfer.

The draft loss through the economizer depends both upon the velocity of the gases and the number of sections. Presumably, the draft loss should vary as the square of the velocity and directly as the number of sections.

The mean-temperature difference between gases and water may be determined approximately by the subtraction of the mean of the entrance and exit temperatures of the water from the mean of the entrance and exit temperatures of the gases, but more properly and more accurately by calculation from the logarithmic formula,

$$\textit{Mean temperature difference} = \frac{ITD - FTD}{2.3 \log \frac{ITD}{FTD}}$$

Where

ITD = Initial temperature difference = temperature of entering gases minus temperature of water leaving.

FTD = Final temperature difference = temperature of gases leaving minus temperature of entering water.

Reports of tests of economizers made according to the preceding form would soon afford sufficient data for more accurate economizer design than is now possible and prevent repetition of errors which have been frequent in past economizer installations. They would also be of great value in comparing the operating results of present installations and in determining whether the results obtained were the best possible, through establishing some basis of comparison.

For tests wherein all the foregoing data cannot be obtained, item 16 may be omitted and by the assumption of an efficiency figure for item 26 (usually taken as 85 per cent.) and of the specific heat of the gases (0.24) the weight and volume of flue gases can be calculated and approximate results obtained as accurate as the assumptions used and at least fairly comparable with other similar tests.

A Pneumatic Steam-Turbine Governor

Practically all governors heretofore used, either on engines or turbines, depend upon the centrifugal force of metal balls or weights opposed by springs or weights, combined with other mechanism, to operate the valves. In a new type of pneumatic governor, designed and now used by the Ridgway Dynamo and Engine Co., of Ridgway, Penn., the distinctive difference is that air replaces the metal balls or weights and also replaces the

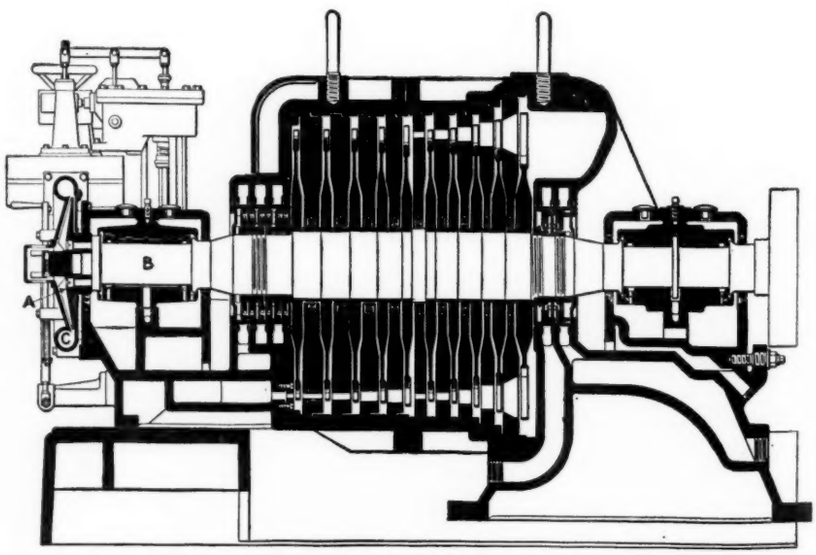


FIG. 1. APPLICATION OF FAN IMPELLER TO THE TURBINE SHAFT

connecting linkage levers, etc., between the centrifugal element and the valves.

Referring to Fig. 1, a small fan impeller A bolted to the end of shaft B is inclosed by the fan housing C and generates an air pressure of about 12-in. of water at

3600 revolutions. This air pressure acts on the under side of two light aluminum pistons *D* and *E*, Fig. 2, forcing them upward. This movement is opposed by the spring *F*. At the upper end of the piston rod *G* the lever *H* operates the pilot valve *I*, which admits oil to and from the cylinder *J*, the piston *K* of which operates the main inlet valves, *L*, *M* and *N*, *N* being an overload valve. The spring *O* is for the purpose of closing the main valve in case the oil pressure should fail for any reason.

A synchronizing motor *P* is for adjusting the speed from the switchboard. *Q* is a worm on the motor shaft and *R* is a worm wheel which engages with the handwheel *S* by means of pin *T*. The speed may therefore also be adjusted by hand with the wheel *S*. An electric contact *U* is for the purpose of breaking the circuit in case the motor is run too far in either direction.

The hub of the fan impeller *A* has a spring bolt *V*, for operating the emergency trip. In case of overspeeding this bolt *V* strikes the hair trigger *W*, releasing the hammer *X*, which in turn strikes the main latch *Y* a blow, releasing the rod *Z* which, due to the spring *A'* closes the butterfly valve *B'* in the steam line. Handle *C'* is in the form of a loose toggle, the lost motion of which permits some movement of *Z* before a movement of the bell crank takes place; thus the inertia of *Z* under movement is used to start the butterfly below the throttle valve.

The pneumatic governor has many advantages. The only running part is a plain disk, with vanes on the side of it, which is bolted to the end of the shaft. Air forms the connecting medium between it and the other moving parts, and these move only on a change of speed due to a change of load. The small pilot valve *I* and piston *K* move in oil and should therefore last indefinitely. The governor as a whole is simple and little subject to wear. The only work to be performed by the air pistons is to operate the small §-in. diameter pilot valve, which is balanced and floats in oil. The air force on these two pistons is about 150 lb. The pneumatic action is therefore quite powerful and reliable. The air pressure generated by the fan is as the square of the speed, and slight change in speed, therefore, is quick and effective in its action.

Oil is used in the power cylinder *J* because it acts like an oil dashpot, preventing jumping, overtraveling or hunting of the main valves, and at the same time it insures long life to these parts. Oil for the operation of the governor is supplied from a branch off the oiling system for the bearings. The conditions of atmosphere may slightly change the speed of the turbine, but these are so slight as to be negligible and need not be considered.

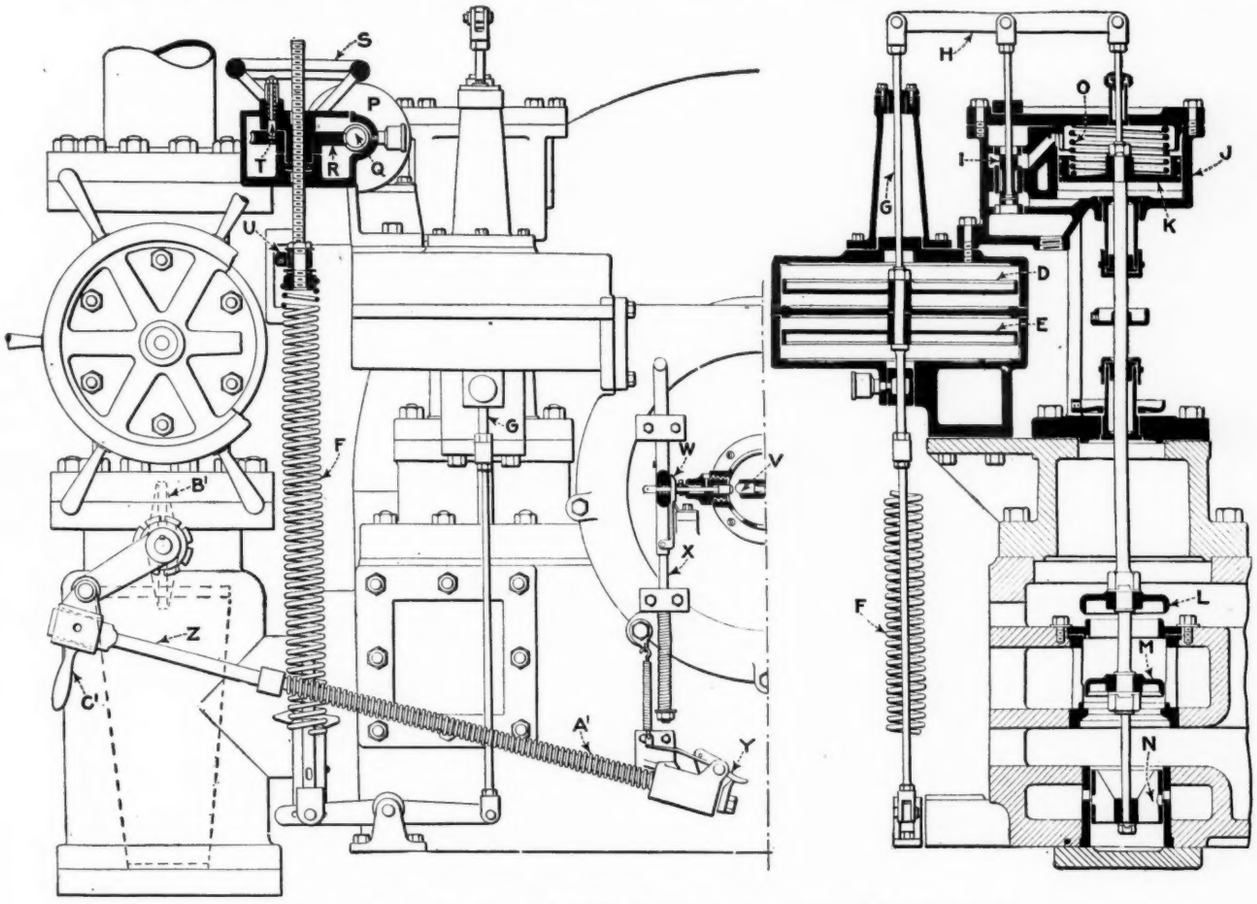
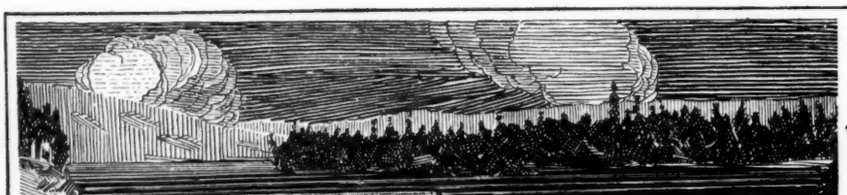


FIG. 3. DETAILS OF THE PNEUMATIC STEAM-TURBINE GOVERNOR

If the boiler horsepower is given, and the chimney height (*H*) is assumed, the required effective area (*E*) in square feet of a chimney may be found by the formula, $E = \frac{0.3\ hp.}{\sqrt{H}}$

For round chimneys the actual diameter should be the diameter of the effective area plus 4 in., and for square chimneys each side should be the side of the square of an area equal to the effective area (that is, the square root of the effective area) plus 4.



POP'S WATER-POWER COURSE

By

John S. Carpenter

JIMMY came in from the cold outside, where the wind blew a young gale, and walked over to Pop's buffet while the good-hearted old chief watched him with a paternal eye.

"So you've got a bad attack of housemaid's knee, hey? Better keep them kind of wimmen off yer knee. But don't look at me like that. Go to it, jes' so you don't git to seein' double. And say! I got the purtiest little turbine drawed up in section that you ever saw!" Pop proudly displayed Fig. 1.

"Why, Pop," said Jimmy, engulfing one of Pop's long black cigars and lighting the half that projected from his face, "you've got such a good sketch there that you don't need any explanation to go with it. I can see all I want right there."

"You can see a lotta things now that you couldn't before you got a strangle hold on that bottle," retorted Pop. "Now git this, son; the only law that amounts to a darn in turbine-runner design is 'Shockless entry and discharge without velocity.'"

"Pop," crowed Jimmy, "no lawyer ever put that into words. Where's all the whereases and whereins? Can you prove that the party of the first part is not pro bono publico in dutcho with the party of the second part?"

"Aw—fergit it. That buffet gits locked up from now on. Now, as I was sayin', so fur as efficiency and power output goes, our lecturer tol' me that he could develop the whole turbine theory from that law. Shockless entry means—er, jes' what it says—that the water gits in, or enters into the turbine without shock. What I means by shock is showed very purty by tryin' to slide your hand along this polished table top by bringin' it down with a bang, instead of by goin' to it and doin' what you want to do, slidin' your hand along it in the first place."

"Can you give me another horrible example from daily life?" inquired Jimmy, slowly getting back to normal.

Pop thought a minute; then he snapped: "S'posin' you tol' Annie, the peach over at the Greasy Spoon Beanery, that she was as ugly as that bullpup I got, and then ast her fer another settin' of them free hot rolls. She'd like you and electrocution the same way. But s'pose you go after it like this, with a dollar's worth of cold cream on every word: 'Say, Annie, when they gave out the good looks you was in the bald-headed row an' got 'em all. Would you mind slippin' me another roll or so?' Then she'd give you all that wasn't nailed down."

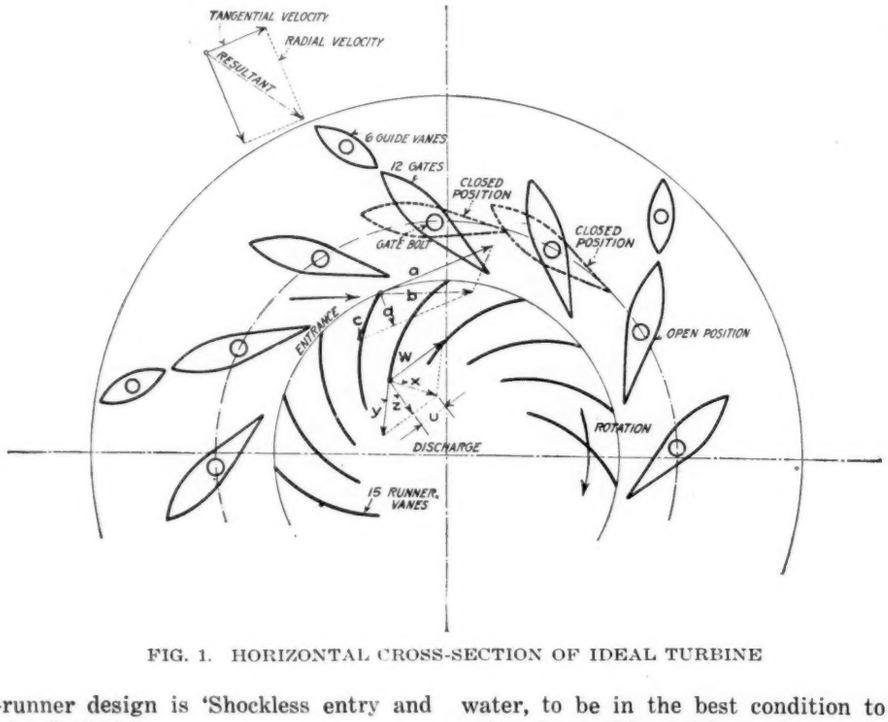


FIG. 1. HORIZONTAL CROSS-SECTION OF IDEAL TURBINE

"You're fulla that stuff, Pop, but I see what you mean. You mean that the water, to be in the best condition to do work, should enter the turbine without shock, which means not to turn it out of the natural path it would follow. Now let's begin with those things that you mark guide vanes on your sketch. Let me see if I can explain it alone. The water comes around the turbine, which is situated in the scroll case, and has two motions—one that is very nearly tangential to the turbine case, and another that is toward the center of the turbine, or radial. To get in without shock, the water must follow a combination of those two movements—what the highbrow fellows call 'the resultant of the two forces.'"

"Fine," exclaimed Pop with no little admiration. "It's not so easy to git them fine points at the first

try. But you forgot to say that the resultant path of the two motions is the angle that the guide vanes should be set at. Now we'll take up the next thing I got marked as wicket gates on my sketch. The guide vanes and the wicket gates form a sort of circ'lar path that the water takes and which should happen at about three-quarters load on the turbine, at which load most correctly designed turbines have their maximum efficiency. For the newest and highest-speed turbines this isn't exac'ly so, the high point of efficiency bein' nearer full load. The gates, by swingin' on this pivot which I calls a gate bolt, opens up more or less on the narrer end, so lettin' more or less water into the runner and—now git this — by so doin' changes the velocities in the runner a great deal. They is gen'ly half as many guide vanes as wicket gates and mos' always two or three more vanes in the runner than they is wicket gates, the reason bein' that if they was the same number of gates as vanes, they'd be a place in every revolution where the ends would be together, that tendin' to set up vibrations in the machine."

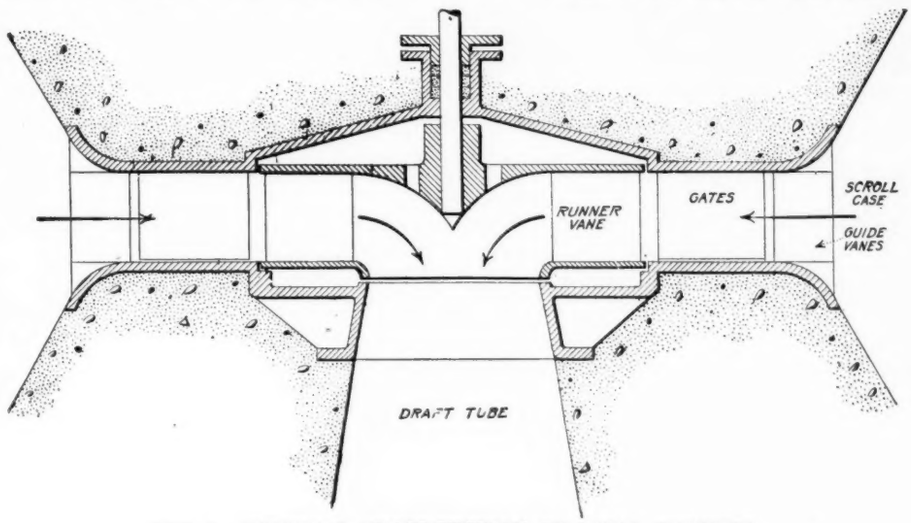


FIG. 2. VERTICAL CROSS-SECTION OF IDEAL TURBINE

"Now, Pop, what's this triangle business here on the entrance to the runner?"

"You mean them things I got marked *a*, *b*, *c* and *d*? Each one of them represents a velocity drawed to some convenient scale. Now *a* is the peripheral speed of the runner in feet per second. In practice it runs from 60 to 95 per cent. of the spoutin' velocity, the mos' ordinary bein' from 75 to 85 per cent. The velocity *b* is the absolute, or really the true velocity of the water enterin' the runner. This velocity varies a hull lot on the different makes of turbines, seemin' to depend more or less on the age and disposition of the boss patternmaker in some cases. We're goin' to see how to do it right, soon. Velocity *c* is the relative velocity of the water to the runner, taken as if the runner was standin' still."

"Relative velocity? What's that? A cousin or uncle by default or something to absolute velocity?"

"S'posin', son, that you was on a train goin' five miles per hour——"

"Now you're talking about the speed records on the Erie or the D. T. & I.," interrupted Jimmy.

"Aw, shet up a minit! S'posin' you was on a train breakin' its neck goin' five miles an hour and you was up at the front end walkin' toward the back at the rate of three miles an hour. Now then, the absolute velocity of the train with respect to the earth is five miles per hour, and the absolute velocity of you to the train is three miles an hour. But git this, kid—the relative velocity of you to the earth is two miles per hour. You're really runnin' backward at the rate of two miles an hour so far as the earth is concerned. You subtracts the speeds in this case 'cause you're goin' in different directions. The three miles you travels backward with respect to the train cancels three of the five miles that the train's goin' the other way."

"And if I was goin' the other way, Pop, I suppose that we'd add the velocities."

"Correct; the three miles you're goin' adds so much to the train speed, making eight miles per hour. Ag'in, if you was runnin' ten miles an hour backward an' the train was goin' ten miles forward, then you'd be standin' plumb still with the earth even though you was ashakin' your ol' bones like the devil to keep up. Git that?"

"U-huh," mumbled Jimmy. "So now you use the same idea on velocities of the turbine runner, and *c* found by those diagrams is the relative velocity of the entering water to the runner vane."

"Yep. I see, Jimmy, that the alcoholic fog is clearin' off," observed Pop with a twinkle in his kindly eyes. Jimmy pretended not to hear the jibe.

"Are the other velocities, *b*, *c* and *d*, any fixed proportion of the spouting velocity, like the velocity *a*?" inquired Jimmy, relighting the cigar butt.

"Yep, but one thing I wants you to git is that each manufacturer makes his turbines to suit his own dear little self and tells the other fellers the place to buy through tickets to, no stop-over allowed. So the standard makes of turbines is about as much alike as a boy-cow and his brother. You can see from them two diagrams that they is at least five things that you can change, and each one makes all the others change. Then, as regards the shapes of the runners, they is as near to bein' alike as Paris styles in two seasons runnin'. If ol' man Bill Shakespeare did turbine designin' fer a livin' instead of takin' real money fer writin', he never would have wrote that purty limerick entitled 'Variety is the spice of life' the way he did, them words bein' by hisself, the moosic by accident."

"How would he have said it, Pop?"

"Oh, he'd 'a hollered, 'Standard turbines is life's chow-chow.'"

The two gravely lighted fresh cigars (from Pop's box) and bent over the table anew.

"Regardin' the discharge side of the runner, so fur as them velocity diagrams is concerned, pretty much the same spiel goes. The velocity *w* is the peripheral speed of the runner at that point, *y* is the relative speed of the water to the runner vane, *z* is the vertical component of the absolute discharge velocity of the water with respect to the earth, and *x* is the true absolute discharge velocity of the water. Now, see that line marked *u*?

That is the amount of velocity that the water has in a tangential direction, and it is jes' this that makes the water go on down through the draft tube in a spiral path. They is a point on the load curve of every turbine where x and z will fall in one line and the line will be at right angles to w. At that load the water will come out of the turbine without any twistin'."

"I've got a hunch, Pop," exclaimed Jimmy. "Now am I right when I say that when the gates open or close, the water velocity in the runner is changed and that swings x to the left or right, as the case may be, because y changes in length?"

"Yep, that's it. When y is quite small the water goes down through the draft tube with a hull lot of twistin' an' keeps agoin' even after it's out in the open stream, a-boilin' and makin' great big bubbles," said the old man.

"Tell us, Pop, what percentage of the spouting velocity z is."

"I tol' you before that it ain't the same on any two makes of turbines, but good designers is fairly well agreed that in what they calls slow-speed runners it's about 3 or 4 per cent. of the total head; in what they calls normal runners it's 5 or 6 per cent.; and in the highest speed runner made today it's about 20 per cent. That means that you find 5 or 20 per cent. of the head, as the case may be, and then find the velocity due to that head. The great trick is to make x as short as possible, for then you get discharge practically without velocity."

"That means of course that so much of the head is lost, then?"

"Not by a jugful! By hickey, no! The draft tube, as I told you before, is a great hand fer turnin' velocity back into pressure when they's taper enough to it. You win a red necktie and a rubber collar fer that one."

"How much of the velocity is gotten back in that way, Pop?" asked Jimmy, sheepishly.

"Of course they's friction to count in, too, but they claims that when conditions is right they can get back about three-fourths of the head that is represented by velocity at the runner discharge."

"I s'pose, Pop, that you'll give us another view of the turbine shown in Fig. 1 so that we can study it better?"

"In Fig. 2 I drawed up about what you wants. Now git me when I says that this ain't anything else than a ideal turbine, 'cause them standard turbines is complicated and it's no wonder that self-respectin' turbine designers goes nutty. We'll first take somethin' we can understand, and later we can rush in where angels fear to tread, as the guy says. Git me?"

"Yes, indeed, Pop. I must admit that you're a genius after all, and I don't see how you managed to conceal it so successfully from the world all these years," said Jimmy with a chuckle.

"And now, you red-headed highball hound, before I puts the coffee pot on the stove and gits out the cake and the pinochle deck, let me tip you off to think a bit about how velocities and areas is figgered; 'cause next time we goes into it up to the hubs!"

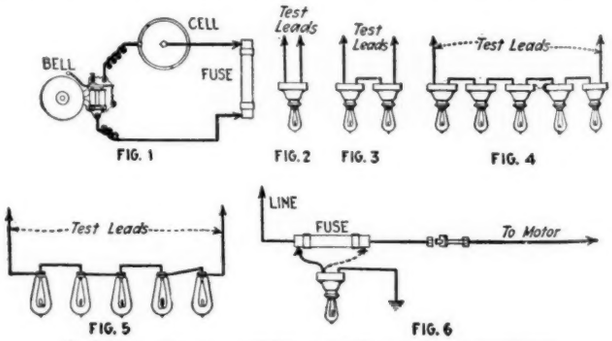
Methods of Testing Blown Fuses

By E. C. Parham

The frequency with which help is sought for trouble that proves to be only a melted fuse or an otherwise defective one makes it apparent that an explanation of the simple method used by maintenance inspectors for locating a blown fuse might interest those who have trouble of this nature to contend with.

IN MANY cases the test for a blown fuse is to try another; if the new fuse happens to be defective or of too low capacity—conditions that quite often obtain—the next step generally is to call for help. Unfortunately, inspection of an inclosed type of fuse frequently fails to disclose its condition. This, in connection with the carelessness with which discarded fuses are permitted to lie around and eventually to become confused with good ones, may result in conclusions that are misleading. The condition of a fuse may be determined by means of a bell circuit applied as indicated in Fig. 1, in which all devices are named. First hold the test lines together; if the bell rings, the test circuit is all right. Then apply the test leads as indicated in the diagram; if the bell rings, the fuse is intact. A lamp and 110-volt circuit may be used in the same way as the bell and battery.

For testing installed fuses a lamp-test circuit of suitable voltage is most convenient; and the voltage rating of the single test lamp or the sum of the voltage ratings of the several test lamps to be connected in series must approximate the voltage of the circuit of which the fuses are to be tested; otherwise the test lamps may be destroyed. One 100-volt to 125-volt lamp provided with leads (Fig. 2) will answer for testing the fuses of an 85-volt to 125-volt circuit. One 250-volt lamp (Fig. 2) or two 110-volt lamps connected in series (Fig. 3) are suitable for testing on circuits of from



FIGS. 1 TO 6. TEST LAMPS AND CIRCUITS

220 to 250 volts. Two 250-volt lamps connected in series (Fig. 3) or five 110-volt lamps connected in series (Fig. 4) may be used on circuits of from 440 to 600 volts.

Where sockets or bases for holding the lamps are not available, the lamp contacts may be connected directly together, as indicated in Fig. 5, and the connections insulated and firmly bound with insulating tape. The lamps should be so connected that both test leads may be soldered to the threaded contact in a secure manner.

Proficiency in tests made with a single lamp or with two or as many lamps in series as the line voltage may require, can be acquired by any operator with but little practice. Fig. 6 indicates the fuse of a ground return circuit of which the ground return conductor includes no fuse. Such a condition is found where the motor frame is grounded and the negative end of the motor circuit is connected directly to the motor frame. Assuming the fuse to be intact and the line to be alive, if one end of the lamp test circuit (here represented by a single lamp) be touched to a grounded part such as the motor's frame, a gas, water or steam pipe and the other end of the test circuit touched successively to the line and motor ends of the fuse, the test lamp will glow. If the lamp glows when the line end is touched but fails to glow when the motor end is touched, either the fuse is "blown" or it fails to make contact with one of its holding clips; inspection will reveal a bad contact.

Fig. 7 indicates the fuses of any two-wire circuit. To make the test first try across the upper ends *A* and *B'* of the fuses in order to determine if the line is alive. If the power is up to the fuses, the test lamp will glow; if the lamp fails to glow there exists an open-circuit elsewhere, perhaps a fuse on the service panel at the outer end of the line. Assuming the line to be alive, next test across the lower ends *B* and *A'* of the fuses. Glowing of the lamp will indicate the fuses to be intact, because the test-lamp current must pass through one fuse in order to reach the lamp and through the other in order to get back to the line. If contact with *B* and *A'* fails to light the lamp, it means blown or otherwise defective fuse or fuses.

Next test from *B* to *B'* and from *A'* to *A;* if both tests fail to light the test lamp, both fuses are open. If one test lights the lamp and the other does not, only one of the fuses is blown and the defective fuse will be the one that failed to light the lamp when the test lead was applied to its lower end. Thus, if fuse 1 is blown, the fact will be indicated by "no light" when one of the test leads is touched to its lower end *B;* and if fuse 2 is blown, this will be indicated by "no light" when one of the test leads is applied to *A'*. In short when the test lamp fails to light, the test lead on the lower end will point to the faulty fuse.

Fig. 8 indicates the fuses of a three-phase, three-wire circuit. To test the fuses apply the test lamp successively across *A* and *C*, *A* and *E*, and *C* and *E;* if all tests light the lamp, it means that line voltage is up to the fuses. Next test across *B* and *D*, *B* and *F* and *D* and *F;* if each of these tests lights the lamp, it means that all fuses are intact. Assuming, however, that failure of the lamp to light indicates one or more fuses to be blown, hold one test lead on *B* and test successively to *C* and to *E;* then hold one test lead on *D* and test successively to *A* and to *E;* then on *F* and test successively to *A* and to *C*. In other words, successively hold the test line on the lower end of each fuse while testing to the upper ends of the two remaining fuses. When one of these tests fails to light the lamp, the defective fuse will be the one on the lower end of which the test lead rests. And this is true whether one, two or three fuses are gone. In any test that fails to light the lamp the lower test lead will rest on the defective fuse.

The diagram applies also to a three-wire direct-current circuit and to a three-wire two-phase circuit, due consideration being given to the fact that in both cases the number of test lamps to be connected in series must be governed by the voltage between the outside lines.

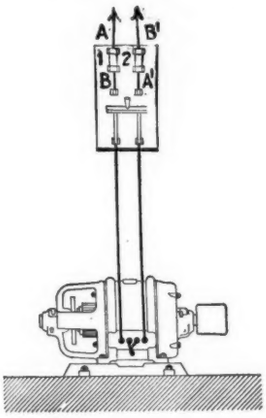


FIG. 7

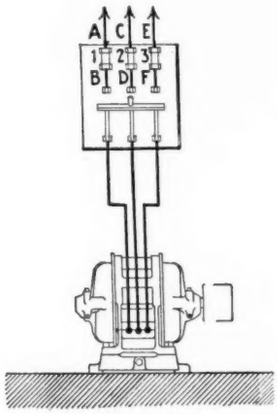


FIG. 8

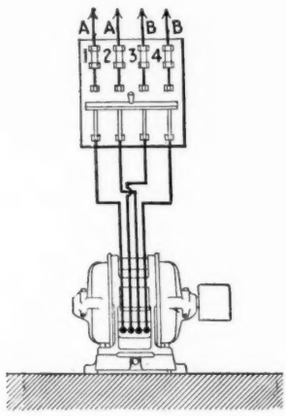


FIG. 9

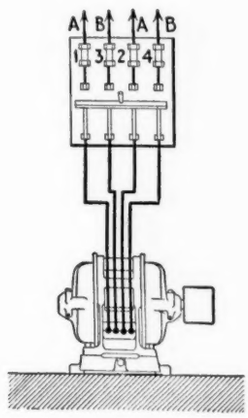


FIG. 10

FIGS. 7 TO 10. SINGLE-PHASE, THREE-PHASE AND TWO-PHASE MOTOR CONNECTIONS

In Figs. 9 and 10 are indicated the fuses of a quarter-phase circuit. In Fig. 9, fuses 1 and 2 of one phase and 3 and 4 of the other phase are adjacent. In Fig. 10 the phase fuses alternate in order; both arrangements are likely to be found. In either event the test for a blown fuse is the same as that described for Fig. 8 and is based on the easy-to-remember rule that the lower end (motor end) of a blown fuse will not light out with either end of any other fuse in the bank. Therefore, on the lower end of each fuse place one test lead and to the upper end of the other fuse of the same phase touch the other test lead; in any test that fails to light out, the test-circuit lead that is on the lower end will point to the blown or otherwise defective fuse.

In making these tests care should be taken to see that the voltage rating of the test lamps approximates in value the greatest voltage to be tested, and that the insulation on the end of the test leads is removed no farther than is necessary to enable the operator to see what he is doing; otherwise the bared end of a test lead may short-circuit two live conductors and produce a flash that is likely to injure the person making the test.

The Electrical Study Course—A Simple Method of Adding Voltages

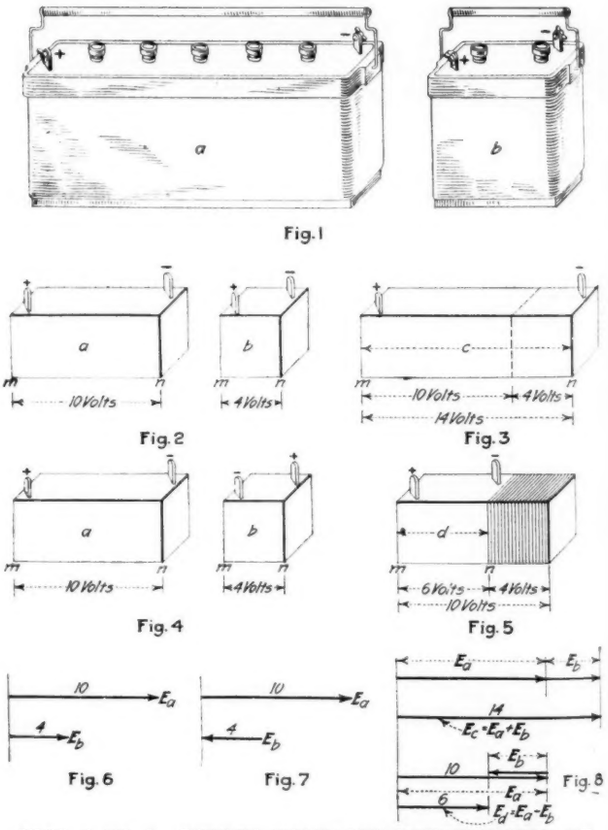
Addition of electromotive forces by the use of straight lines as applied to direct voltages is first presented, and this is then developed to embrace problems into which phase difference enters, as in the case of alternating voltages.

IN FIG. 1 are represented two storage batteries, *a* and *b*, whose voltages are 10 and 4 volts respectively and whose polarities are as indicated. Since there are more cells in *a* than in *b*, we could indicate the voltages of the batteries by their lengths, as for example, in Fig. 2. If they were to be connected in series, the total voltage would be 14 volts, and if all the cells were placed in a single case *c* instead of two separate ones, the length of the case would be equal to $a + b$, as indicated in Fig. 3. The length of *c* would therefore indicate its voltage.

Suppose, now, that the polarity of *b* is opposed to that of *a*, as represented in Fig. 4. If the cells were to be connected in series under these conditions, the total voltage would be 6 volts. That is, the cells in *a* would be opposed by those in *b*. This condition is shown in Fig. 5, where the shaded portion indicates the part of battery *a* that would be required to overcome the voltage of battery *b*. The result is that we have a battery that is equivalent to the cells contained in the part *d*.

Instead of showing an entire battery, we could use its base line *mn* to indicate its voltage. Thus the voltages of *a* and *b* in Fig. 2, could be represented by the lines E_a and E_b in Fig. 6. The voltage of both is in the same direction—from left to right—and this fact can be shown by placing arrows at the ends of the lines, as is done in Fig. 6. If the polarities were those of Fig. 4, the arrows would have to indicate the directions shown in Fig. 7. The lines in Figs. 6 and 7 could be combined in the manner indicated in Fig. 8 in order to get the results given in Figs. 3 and 5. Hence, if the voltages are in the same direction, we add one line to the next, and if they are in opposite directions we deduct the shorter line from the longer; the direction of the remainder is that of the longer line.

The method just described works satisfactorily when dealing with direct-current voltages, because these are either in the same direction or diametrically opposed, and so can be added or subtracted without difficulty. In the case of alternating voltages, however, we may have two voltages that make an angle with each other, which alters the conditions. To solve such cases, let us look upon the voltages as forces. We may do so because they are, in fact, electrical pressures. Thus, let us conceive of a weight, represented in Fig. 9 by *M*, that has two ropes *H* and *K* attached to it, by means of which it is pulled along. Suppose that two men pull on *H* and *K* in the direction of the arrows, with a force of 120 lb. and 80 lb. respectively, as indicated by the lengths of *H* and *K*. Assume, further, that a pull of 120 lb. will move *M* from *a* to *b* in one minute. Then a pull of 80 lb. would move it a distance equal to *ac* in the same time. Suppose that *M* has been moved from *a* to *b* by the man on *H* alone, and that the man on *K* then pulls it alone for a minute. He will move it through the distance a_1c_1 equal to *ac*, so that the final position will be *d*, such that $ad = ab + ac$. This is the same position it would have reached if dragged for one minute by the effort of one man pulling with a force of $120 + 80 = 200$ lb., as represented by *P*. It will be noted that this method amounts to the same thing as the one illustrated in Fig. 8, and the distance moved is proportional to the force. In Fig. 9 *ac* is made two-thirds as long as *ab*, since 80 is two-thirds of 120. This is usually referred to as laying the forces off to scale. Thus if we let a length



FIGS. 1 TO 8. DIRECT VOLTAGES REPRESENTED BY STRAIGHT LINES

of one inch represent 40 lb. or volts, then 120 lb or volts would be represented by a line 3 in. long, since 120 equal 40 × 3, and 80 lb. would be represented by a line 2 in. long.

Suppose now, that the men separate, so that they pull on the ropes in the directions indicated in Fig. 10. If *H* pulls alone for one minute, he will move *M* from *a* to *b*. If *K* then pulls for a minute, he will move *M* through a distance a_1c_1 equal to and in the same direction as *ac*, to the point *d*. The combined effect of *H* and *K* for one minute would therefore be to move *M* from *a* to *d*. Hence the sum of the two forces is equivalent to that exerted by a single man pulling with a force *P*, equal to the length of *ad*, in the direction

of the arrow. In the case illustrated, this force P is equal to 126 lb., as can be found by scaling the three sides ab, a_1c_1 and ad.

What we have really done in the foregoing is to add line ac to line ab, just as we added ac to ab in Fig. 9 in order to get the sum ad. In the latter case the two

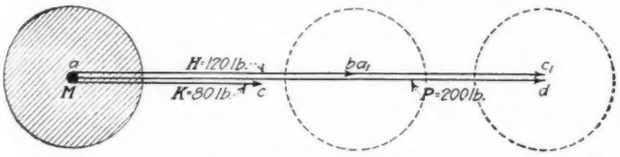


FIG. 9. ADDITION OF TWO FORCES ACTING IN THE SAME DIRECTION

forces act in the same straight line, so when we place them end to end they form a third straight line whose length is measured from the beginning of the first to the end of the second. In the former case, however, the forces act in different directions, so that when we place them end to end they do not lie in a straight line, and the sum of the two is therefore not equal to their combined lengths. It is, however, equal to the length measured from the beginning of one to the end of the other—as from a to d in Fig. 10—just as in the straight-line problem of Fig. 9.

In place of forces in pounds, the lines ab, ac, etc., could be used to represent electrical pressures in volts. Consequently, if we had two alternating voltages, differing in phase, connected in series, their sum could be found by a construction such as that in Fig. 10. Such additions of forces or voltages are called vector additions, because the lines ab, ac, etc., are vectors that represent the quantities to be added.

In Fig. 11 curves A and B represent two voltages 90 deg. apart. The resultant curve C is obtained by combining the instantaneous values of curves A and B. The maximum value of the resultant curve may be obtained by the use of vectors, as shown in Fig. 12. Assume the maximum values of A to be 150 volts and that of B 100 volts. Then, if a length of one inch is let to represent 100 volts, the maximum value of

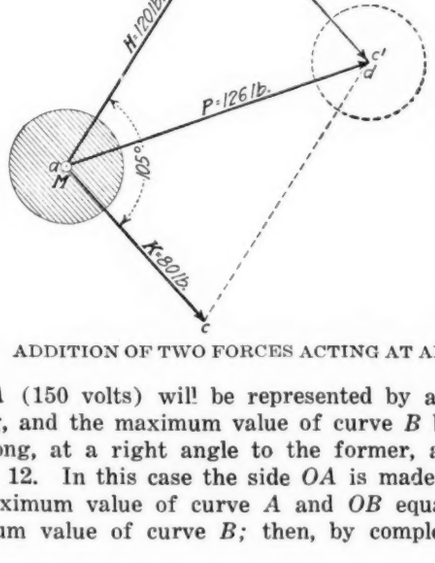


FIG. 10. ADDITION OF TWO FORCES ACTING AT AN ANGLE

curve A (150 volts) will be represented by a line 1.5 in. long, and the maximum value of curve B by a line 1 in. long, at a right angle to the former, as shown in Fig. 12. In this case the side OA is made equal to the maximum value of curve A and OB equal to the maximum value of curve B; then, by completing the parallelogram as indicated by the dotted lines BC and AC, the diagonal OC will equal the maximum value of curve C, Fig. 11, which in this case is $\sqrt{(150)^2 + (100)^2} = 180.3$ volts. This would also be true for the effective values of curves A and B.

As another example find the resultant voltage of two equal voltages 120 deg. apart, as shown by the curves A and B, Fig. 13. Here it will be seen that the resultant curve C is the same as either A or B. In this problem also, the maximum value of the resultant curve may be obtained by a vector diagram, as in Fig. 14. Here OA and OB are drawn 120 deg. apart and equal, to scale, the maximum values of curves A and B. Then the parallelogram is completed by the dotted lines BC and AC and the diagonal OC drawn. In the diagram, Fig. 14, OC equals OA or OB, which checks up with the condition in Fig. 13, where the maximum value of curve C is equal to the maximum value of A or B.

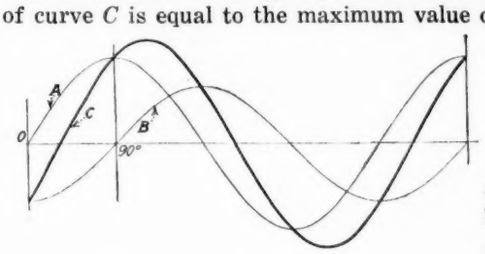


Fig. 11

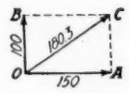


Fig. 12

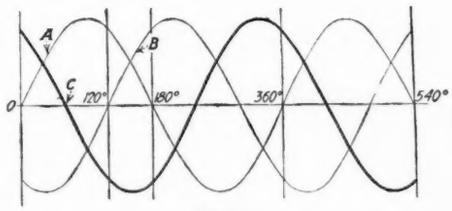


Fig. 13

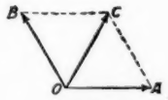


Fig. 14

FIGS. 11 TO 14. ADDITION OF TWO ALTERNATING VOLTAGES OUT OF PHASE

It is frequently possible in alternating-current work to solve easily by the vector-diagram method, problems that otherwise would involve complicated formulas.

The problem of the preceding lesson consisted of determining the effective value of an alternating voltage whose maximum value is 311.13 volts. Also to find the value of the current that it would cause to flow through a resistance of 4.4 ohms. The second part of the problem was to compute the maximum value of voltage of a source that registered 120 volts on an alternating-current voltmeter. From the preceding lesson we know that effective volts = maximum volts $\times$ 0.707, therefore in the first part of the problems we have $E = 311.13 \times 0.707 = 220$ volts, where E represents the effective voltage. If a resistance of 4.4 ohms be connected across this voltage, the current would be $I = \frac{E}{R} = \frac{220}{4.4} = 50$ amperes. In the second problem we are given the voltmeter reading; this indicates the effective value. We are required to find the maximum value of the voltage. In this case we have 120 = maximum volts $\div$ 0.707, from which we get that maximum voltage = 120 $\div$ 0.707 = 169.70 volts.

Two voltages, 100, 150 voltages respectively, are are 120 deg. apart from one another. Draw a vector diagram showing what is their sum. What would be their sum if each of them was equal to 100 volts?

The Infringement of Patents

By Chesla C. Sherlock

Generally speaking, the patent laws of this country seek to confer upon the patentee an absolute monopoly of the right to make, use and sell his invention. But in the practical working of the machinery that has been constituted to enforce these rights, many inventors find that a disgraceful situation exists in regard thereto. Infringement of a patent is a constant temptation to established interests, especially when the inventor and patentee is of limited resources, and the chances that the patent will be infringed increase in proportion to the money value of such patent.

Those who are unscrupulous enough to infringe a patent and who are further fortified with ample resources can keep up continuous litigation in first one circuit court and then another, until the patentee is either exhausted in money or patience, or the full term of his patent has expired. This is not a fanciful supposition. It is a situation that exists.

Testing the Validity of a Patent

As soon as a patent is infringed and the patentee charges the infringer of infringement, the latter immediately sets up the defense that the patent was not valid. This, of course, ends in litigation in order to test the validity of such patent. The practice has so grown up that the mere issue of a patent from the Patent Office does not signify anything. The patentee will have to have the courts pass upon the matter before he can rest from his labors with any real assurance. This means a long legal battle, often extending over a period of years. The courts are crowded with cases. Delays arise and one thing or another will often serve to postpone the decision for five or ten years. In the meantime the wealthy infringer is going ahead manufacturing the invention and reaping his profits.

If the patentee succeeds in winning the verdict in that circuit, the chances are that he will have to begin all over again in another circuit and go through the same process. There are eight circuits in the country, and until the patentee has conclusively won or lost in all of them, there is a marked possibility of his finding himself deprived of the just rewards for his invention. A dishonest infringer can thereby comparatively easily reap the profit that justly belongs to another. He can manufacture the invention and sell it all over the United States; he can then attack the validity of the patent and delay the proceedings in one or two circuits the full term of seventeen years during which the patentee is granted an absolute monopoly by the Federal laws. If he loses there, he still has a large share of profits that the patentee was unable to levy on simply because of the system and the machinery that we have established to enforce the patentee's rights.

Very often studied attempts are made by those in competition with the patentee of an important invention to avoid infringement, but at the same time to imitate the successful device so as to be able to meet the competition it offers. But as a rule studied attempts to avoid infringement end in disaster.

Infringement cannot be avoided by a mere variation of form or size or by the substitution of different material. A marked improvement in an essential part must be made if infringement is to be avoided. Contrary to the general opinion, the mere substitution of one part for another or the omission of a minor part in the device will not avoid infringement. If any omission of parts is to avoid the infringement, then such omission must be of an essential part of the device.

The patent grants to the patentee the sole right to make, use and sell the invention for a period of seventeen years. But the manufacture, use or sale of a patented article is not the sole requisite to its infringement. It should be kept in mind that a mere intention to do any of these things is sufficient. One may have the right to do certain things with a patented article, by reason of his agreement with the patentee and still be an infringer of the patent. Suppose that one person is given territorial rights on a boiler for a certain term by the patentee. He has the exclusive right to sell the boiler in the said territory, but he sells a number outside his own territory. He is, by reason of those sales, an infringer of the patent, because he has violated the license granted by the patentee. The same case arises in the use of the patented article. The patentee may limit the uses to which the purchaser or licensee may put the patented invention. If the purchaser violates this limitation, he is guilty of infringement.

As to who may sue for the infringement of a patent, any one of five persons may bring suit, all five standing in a representative capacity of the patentee. They are: (1) Patentee; (2) a sole assignee; (3) owner of exclusive right, in his own territory; (4) executors; (5) administrators. Jurisdiction in such cases is in the United States Circuit Courts and decisions are appealable.

To enforce his rights in case of infringement, it is necessary for the patentee to give notice to the infringer that he is infringing the patent. This must be accomplished as a sort of preliminary step in enforcing the legal rights conferred by the patent, and it is a polite warning to the transgressor to cease his transgressions.

Patented Articles Must Be Fully Marked

Another requisite to enforcing patent rights against possible infringers is that all patented articles must be fully marked. Many manufacturers are content merely to use the term "patented," not caring to convey to the possible infringer information that he would be particularly desirous of knowing, while others are equally anxious to give a full list of all patents and their dates. Some manufacturers even offer to furnish full data to possible infringers concerning their patents.

Where the patent is not given upon an entire machine or device, but is expressly limited to a part or specific parts, a change in the number of parts will avoid infringement of such patent. Thus, if a patent were expressly granted on six parts and a device was brought out with only five parts, the latter device would not infringe the patented one. The same thing is true in cases where a patent has been granted on the form or design of a machine or appliance. But a mere change in form or design will not avoid infringement unless the patent was limited to a particular shape or form.

If repairs are made on a patented machine by one having no license from the patentee, such repairs are an infringement when they change the identity of the machine. The idea is that by repairing the patented machine in such a way as to change its identity the patentee has been deprived of profits justly due him.

It is a general principle that a patent is valid until proved void and that the patentee is entitled to the full protection of the laws to enforce his rights under it, and the tendency to lay them open to the tricks of legal wits should be and is being discouraged on all sides.

EDITORIALS

The Government and the Power Plant

NOBODY begrudges the money that is spent by the Department of Agriculture in the extermination of cattle and plant diseases, the control of destructive insects and the propagation of the many methods which result in an improved and more abundant food crop.

Is there any reason why another appropriate department of the Government cannot do as much for industry?

Is there anything more important than the fuel supply? We had in the shortage of two years ago an intimation of what would happen if it failed. Next to air and food and water, it is the most vital of all the essentials; and yet with what little thought and intelligence and systematic oversight are we rushing it through its wasteful reduction to ashes!

Do we appreciate the part that power plays in modern life—a part so overwhelmingly important that it is difficult to realize that the father of the steam engine has been dead only a hundred years? Imagine for a moment what would happen—or rather, would fail to happen—if the fuel-produced power of the country were to stop. No light, no water, no newspaper, no train or trolley or ferry, no elevator, no motion to the machinery in the shop, and if it lasted more than a few days, no food or fuel in the house.

Power enters into the cost of everything that we buy, of nearly everything that we do. If it is not involved in its production, it is in its transportation and distribution. Is it not of extreme public importance that it be efficiently produced and economically used?

When, under the stress of war conditions, it became necessary to conserve coal and save power, the Government was aroused, and even the hurriedly gotten together organization working under the disturbed conditions of those troublous times produced phenomenal savings by the simplest means. In one manufacturing community some thirty per cent. of the coal used in the industries was saved without interfering with production. This had to be done in war; is it not good to do in peace?

In the Department of the Interior there is an organization already endowed with the authority, if it could be provided with the means, to carry on much of this beneficent work. The act creating that Bureau reads:

> It shall be the province and duty of the Bureau of Mines . . . to conduct inquiries and scientific and technologic investigations concerning mining and the preparation, treatment and utilization of mineral substances with a view to improving health conditions and increasing safety, efficiency, economic development and conserving resources through the prevention of waste in mining, quarrying, metallurgical and other mineral industries; to inquire into the economic conditions affecting these industries; . . . to investigate the mineral fuels and unfinished mineral products belonging to or for the use of the United States, with a view to their most efficient mining, preparation, treatment and use; and to disseminate information concerning these subjects in such a manner as will best carry out the purposes of this Act.

While this may not authorize the direct intervention in the operation of private plants that was practiced to such good effect in war time, it affords a basis upon which the department could do such research and advisory work as is done by the agricultural bureaus; and really in the coal and power crisis it was advice and direction, readily accepted and followed by the power users, which did the most good. One of the most natural and logical commencements for its activities in this direction would be to keep the coal that is shipped from the mines up to a standard of quality or to the specifications of a given purchase. One of the most outrageous economic crimes of the war was the shipping of tons and tons of worthless rock over an overburdened railway system and selling it to the power plants and factories of the country at two or three times the price of good coal. As usual, the consumers of their products had to pay the freight. Unfortunately, the Bureau has not the means to do this work gratuitously for individuals, but it is doing much of it for Government departments, etc., and is better equipped to handle such service than any other branch of the Government. Perhaps arrangements could be made whereby the Bureau would sample and report upon coal shipments at the cost of rendering the service. This activity might naturally lead to an extension of field of usefulness of the Bureau in advising upon and encouraging, if not of insisting upon, the use of fuel and of power with some degree of economy. The cost of wastefulness in this respect is borne by the ultimate consumer, and that is the people as a whole; and the people as a whole, through their Government, ought to have something to say about it.

Pulverized Coal for Boiler Furnaces

PULVERIZED coal again is in the spotlight. Periodically it emerges from back stage, attention is focused upon it and, its latest act over, it goes back again. But each new act is better than the previous one, and the house more crowded with an interested audience. Its progress encourages.

In this issue considerable space is given powdered coal and much of value is told about it. Rightly, the authors lay emphasis upon the necessity of fine pulverization and adequate furnace volume. These are essential to success, for each fine particle must be surrounded with air for combustion and the gases move at low velocity. Neglect to fulfill these requirements has led to the failure of most pulverized coal installations.

Until there is a greater difference in cost between pulverized coal preparation and burning and the combustion of coal on automatic stokers, many engineers will not be won over to it. High-volatile coal makes the best of all pulverized coal. But it is also the most valuable from the broad economic standpoint, because of the hydrocarbon chemicals to be had by distilling off the volatile. It may be several years before anything of considerable volume is done in the way of distilling off this volatile, but sooner or later high-vola-

:ile coal will pass through this kind of a process before it becomes available for power plants, and rightly so. It is nothing short of criminal waste to do otherwise, inasmuch as the heating value is so little lowered.

Of considerable interest is the description of a method of burning ground coal as told by W. L. Abbott, chief engineer, Commonwealth Edison Co., Chicago. The inventor informs Mr. Abbott that the largest size of the coal particles should not be greater than will pass through a one-eighth inch round hole. The particles are, therefore, of large size compared with pulverized coal sizes. It is not necessary to dry the coal before using it. It is burned in a circular furnace, the ash dropping away and solidifying before reaching the bottom of the furnace. The experimental furnace is three feet in diameter and will burn about three thousand pounds of coal an hour. Mr. Abbott says that Professor Young, of Purdue University, who has made a test of it, reports combined efficiencies above seventy per cent., which is high for Illinois coal.

Power Factor in Polyphase Circuits

SINCE the generator, line and transformer capacity required in a given alternating-current system varies inversely as the power factor, and the copper losses vary approximately inversely as the square of the power factor, it is evident that, especially where large amounts of power are involved, power factor of the system is a very important item in the generation, transmission and distribution of electrical power. Putting the foregoing statement into figures, it may be said that to supply a given load at fifty per cent. power factor will require twice the generating and transformer capacity and there will be four times the losses in the transmiss'on and distribution system as to generate and transmit the same kilowatts at unity power factor, not considering the deleterious effects on the voltage regulation both of the generator and the lines. For this reason the power factor has always been of serious concern to those interested in the generation, transmission and sale of electrical energy. There is a pronounced tendency on the part of central-station companies to base their rates for electric power on the power factor of the customer's load. However, before this can be intelligently done there must be some recognized standard definition of and method of measuring the power factor of polyphase circuits.

The power factor of single-phase circuits is easily defined—it is the ratio of the true power as measured by a wattmeter, to the apparent power as obtained with a voltmeter and ammeter; or, as it is frequently referred to, "the cosine of the phase angle between the current and the voltage." However, a definition of the power factor of polyphase circuits has never been agreed upon by electrical engineers. In balanced loads the numerical value of power factor varies but slightly with different definitions, but where the load is unbalanced, with different phase relations between the current and voltage of each phase, considerable variations may be obtained in the power factor when expressed according to the various definitions.

There has been appointed a special joint committee of the American Institute of Electrical Engineers and the National Electric Light Association on the determination of power factor in polyphase circuits. It is the purpose of this committee to establish for power factor in polyphase circuits a definition which shall be universally applicable to all polyphase circuits, whether balanced or unbalanced and which shall satisfactorily take into account the various considerations involved in the commercial and technical uses of the term and in devising methods and instruments for its measurement. The findings of the committee will no doubt be looked forward to with much interest by all those concerned, since, as pointed out in the foregoing, there cannot be an intelligent application of the function known as power factor to the commercial engineering and scientific aspects of the electrical art until some standard definition and method of measurement is adopted.

Andrew Carnegie

LANDED in the cheerful precincts of Barefoot Square, Slabtown, Penn., at the age of thirteen, his father's business ruined by the very development of the industry, put to work as a bobbin boy at twenty cents a day—not a promising outlook. And yet he left a half billion of dollars after spending the last quarter of his life trying to give money away as fast as it came to him, because he deemed it a crime to die rich.

He did not stay long as a bobbin boy; he found he could get more money firing boilers. He saw still better pay and more contact with the world in the life of a telegraph messenger and he got a friend from his old Scotch home to help him become one. And then he took advantage of the opportunity which access to the instruments afforded him to learn telegraphy, and became a railroad operator. There were other messenger boys who did not become operators. One day when his superintendent was away there was a train wreck. Carnegie did what he knew his superior would have done if he had been there and did not shirk the responsibility of signing his superior's name to his orders. The ability, initiative and resourcefulness thus displayed won the appreciative attention of the superintendent, who made the boy his secretary and helped and advised him to make investments which gave him his start in life. There were other telegraph operators, but they did not become multimillionaires. Without that restless reaching out he might have worked in a fireroom all his life. If he had been contented to read cheap novels and talk baseball instead of training hand to key and ear to sounder, he would never have become Scott's operator. If he had spent his let-ups in frivolous day dreams or in watching the clock, he would not have had the grasp upon his superior's duties and methods which enabled him to jump into the breach and make an influential patron of his employer.

In these little things better than in his larger operations can be seen the characteristics which made him the master of iron, of finance and of men.

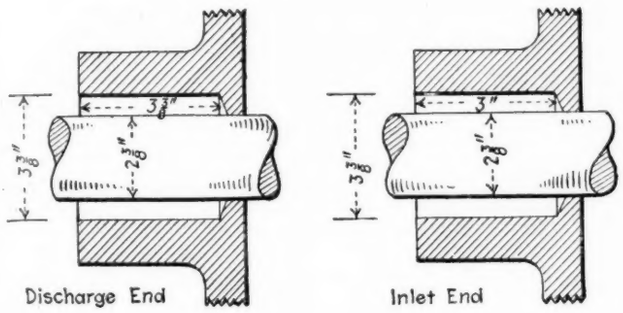
As an investment proposition the good workman represents a greater risk than a good machine. When the machine breaks down, you can have it fixed up and you still have the same machine which you have learned to make work the way you want it to. When the workman breaks down, you have to spend a lot of time training a new man to work the way you want him to.

The wise employee asks questions about the work. The other fellow doesn't have to—so *he* thinks.

Correspondence

Send Sketch with Packing Order

I have found it convenient, when ordering packing, to send to the manufacturers a sketch drawn on ordinary cross-section paper. This paper can be bought in 6 x 8-in. pads, which is a handy size for general sketching. It is not necessary to draw to scale, but if all dimen-



SKETCHES GIVING PACKING SIZE

sions are given, as shown in the illustration, the chances of getting the wrong size packing are reduced to a minimum. W. H. MOORE.

Paterson, N. J.

Concrete Boiler Setting

The description of the concrete setting of boilers at the Robert Gair plant in Brooklyn, on page 934 of *Power* for June 17, recalls an experience that we had with concrete used in boiler-room construction several years ago. We were called to make an economy test of a plant and noticed that a concrete column that had been put up between two boiler settings was disintegrating. As quickly as we could we put in a structural-steel column and beam and removed the concrete structure which was getting ready to crumble.

Concrete is far from fireproof, and it disintegrates under a very moderate sustained heat. A day-in and day-out average temperature of around 110 deg. F., 100 deg. at the floor and 120 deg. at the ceiling, disintegrated that column in about three years. The column stood in a passage between the settings and did not touch either of them. ROBERT MCLAUGHLIN.

South Philadelphia, Penn.

Cleaning Handhole Plates

To clean handhole plates of water-tube boilers, place them in a barrel containing water and insert a steam lance, and after adding some caustic soda, boil. The bolts and crabs can also be cleaned in this way, but the threads on the bolts should be oiled as soon as taken from the water. If this cannot be done at once, leave them in the water and see that they are covered; this will prevent them from rusting. H. M. BOTTS.

Peoria, Ill.

Slow Engine Speed and Condensation

In the July 15 issue of *Power*, page 116, under the heading, "Slow Engine Speed and Condensation," I see Franklin Cheney is bothered with the same trouble we had with the engine that drove our stokers.

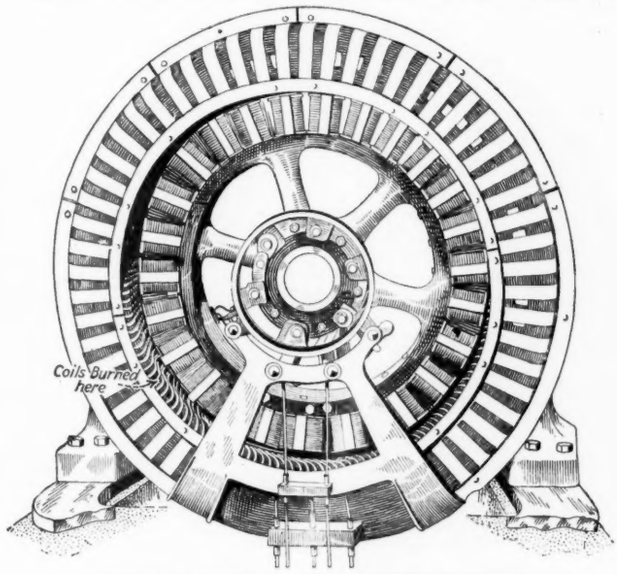
When the steam pressure was up, a diaphgram valve would check the speed of the engine so that it would just turn over, and then the pipes would fill with condensation, which would be carried to the engine as soon as the speed increased. This caused pounding and considerable packing trouble, and then the water would get in the oil in the crank case.

We eliminated this trouble by connecting a steam trap to the valve chest of the engine, which takes care of practically all the water.

Toledo, Ohio. J. N. WOODRUFF.

Burned Generator Laminations Heated

On one of our steam-driven direct-connected generators the frame shifted far enough for the rotor to rub on the stator, injuring the coils at that point. This was possible because the generator frame was not doweled and there was nothing to hold the frame in place when the anchor-bolt nuts worked loose. I



SHOWING WHERE COILS WERE BURNED. BEARING NOT SHOWN

first shifted the frame to one side, drove out the wedges holding the coils of the stator in place, which were burned, rewound about ten coils and put in new wedges. When the machine was tried, the laminations got hot at this point in about twenty minutes. Then I shifted the frame over and filed the laminations smooth where they had been burned so that each was separated from the other. After adjusting for clearance, the machine ran just as well as ever.

Vegreville, Alta., Canada. H. R. JOHNSTON.

Voltage of Generators Varies When Being Paralleled

Compound-wound generators should have separate equalizer switches for paralleling the series fields and equalizing the current in the series-field circuit before the generators themselves are paralleled. The trouble complained of in the letter, "Voltage of Generators Varies When Being Paralleled," by Mr. Armstrong on page 326 of the Mar. 4 issue, was due to his using three-pole switches on his generators instead of single-pole switches, Fig. 1, or a single-pole and a double-pole switch, Fig. 2.

With the three-pole switch open on the incoming machine, there was no current flowing in its armature, hence its series field was not excited. When the switch was closed on the bus with the running machine, the series fields of both machines were paralleled and the current in the series-field circuit equalized on both generators, energizing the series field of the second machine, raising its voltage and that of the bus, and causing it to take the load until its shunt field was regulated to lower its voltage and the load properly apportioned between the two machines. Similarly, in taking a machine off the line, as soon as the switch was opened the load on that machine was dropped over on the one remaining on the bus; and at the same time the series-field circuit was reduced by one field, causing a drop in the bus voltage until the remaining machine had picked up the load and its series field had raised its voltage. With generators of different capacities this disturbance would be aggravated by putting on or taking off a larger unit than the one running.

The difficulty could best be overcome by replacing each three-pole switch with three single-pole switches. The equalizer bus need only be run between the machines, instead of bringing its cables back to the switchboard, the common practice being to locate both the equalizer switch and the switch on the compounded

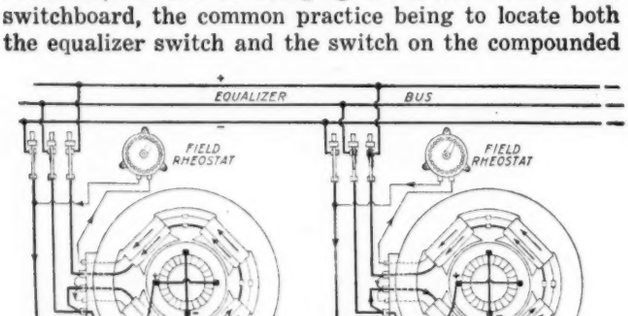


FIG. 1. GENERATORS CONNECTED IN PARALLEL BY SINGLE-POLE SWITCHES

side of the generator, either directly on the machine frame or on a pedestal close to it. The shorter the run of equalizer cable and the less resistance in it, the better will be the regulation between machines.

When putting a machine into service with this switching arrangement, the equalizer switch and the switch connected to the series-field winding are closed after the machine has been brought up to voltage. This connects the series-field winding of the incoming machine in parallel with the series-field windings of the machines already on the system. The voltage on the incoming machine is again adjusted to the correct value and the armature switch closed, after which the load is divided among the different machines by adjusting the field rheostats. It should be easy for Mr. Armstrong to saw through the fiber crosspiece of the three-pole switches and convert them into one two-pole and one single-pole switch as in Fig. 2.

With a little experimenting it should be possible to determine the amount by which the incoming machine must be lower in voltage than the bus, in order to compensate for the machine's rise in voltage when its series field is excited. Likewise, in taking a machine off the bus, its ammeter needle should be a shade to the reverse

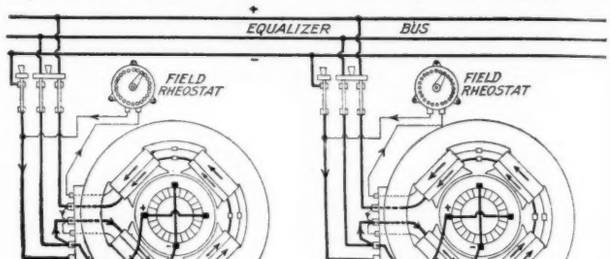


FIG. 2. GENERATORS CONNECTED IN PARALLEL BY SINGLE-POLE AND DOUBLE-POLE SWITCHES

side of zero rather than to the generating side. These are both delicate points, requiring a little study of the actions of each machine; for care must be taken not to lower the voltage of any machine sufficiently to reverse it.

FRANK GILLOOLY.

Philadelphia, Penn.

Making Diesel Operators From Steam Engineers

The letter, "Making Diesel Operators from Steam Engineers," by Waldo Weaver, on page 292 of the Feb. 25 issue, is one that manufacturers of internal-combustion engines should take to heart. A well-known manufacturer of a semi-Diesel engine, with whom I have had some dealings, puts out in his literature, as well as through salesmen, something like this: "Our engines are so simple that anyone can operate them, and a high-salaried engineer is unnecessary."

This may be a good selling point, but selling an engine is only the start, and a manufacturer who sells his engine by that method is sure to lose in the long run because the statement is not a fact.

There have been sold thousands of engines in which some part has proved defective, but as a rule the defective part can be replaced or repaired with little expense. The manufacturer who says his engine does not require a first-class engineer to operate it is putting in his engine a defective part that is hard to repair or replace, and it usually costs money to do either. The only exception is where the engine is smaller than 50 horsepower. The engine manufacturer already referred to one time sold an engine to a concern in the ice business to drive an ammonia compressor. The plant as a whole was modern in every detail. A couple of sledge-hammer engineers were hired to operate it, although neither of them knew anything about an ice plant or an oil engine. However, one was a good machinist. The first thing to happen was the cracking of a cylinder head on the engine. A new head was wired for, and a nice little thing weighing a "couple of tons" came by ex-

press. It lasted a couple of weeks and then cracked. Another new one was ordered, and at the same time the factory was asked to send one of their experts to run the plant for the rest of the ice season, which they did. The expert knew the oil engine all right, but he did not know what he was pulling with it, and I understand he cracked two more heads before the end of the season. A new head, a new piston and reboring of a cylinder were necessary to put the engine in shape to operate.

To further mess things up, they ordered the piston a certain size and then bored the cylinder. When the bar was set up, they found the cylinder cut out on the lower side only, and to make the new bore fit the piston, they lowered the bar and bored the cylinder one-half inch out of center. This was the condition of things when I took charge. I also found the piston $\frac{3}{16}$ in. too small, and the cylinder being bored off center and the piston of the cone-head type, naturally the piston had no clearance at the bottom of the cylinder head, but at the top there was lots of it. I took away liners from one side of the wristpin brasses and added them to the other side, which shortened the connecting-rod and gave just enough clearance for the piston to miss the head on the scavenger stroke. I ran that plant without trouble through one of the hardest ice seasons the country ever saw and made as much in 21 days as was made during the previous year. This was not because I knew more about the engine than the expert, as I am satisfied he is a good oil-engine man, but was due to the fact that I knew what that engine had hold of and he didn't. He regulated the engine to fit the load, and I regulated the load to fit the engine. His trouble was overload and he didn't know it.

But this owner still thought the engine could be run by anyone, so he decided I was too expensive. However, once or twice each year I get an offer of that same job, and at a salary considerably larger than I was then asking. The plant has made very little ice since then, all due to the fact that that engine was sold with that defective part, "so simple anyone can run it."

Now, as to making Diesel operators from steam engineers: The old reliable steam engineer has an advantage over one who has had no experience with boilers. This advantage is, the operator is careful and is sure he is right before he turns things loose. But he is at a great disadvantage, that the old steam engine has taught him, which is overload. The steam engine is built to use as little steam as possible—that is, as as a rule they are—and to build them to operate economically their rated horsepower is below the real power they will develop. All one has to do to a steam engine of small capacity in order to increase output is to put on the load, and it takes it day after day and year after year.

On the other hand, the oil engine is the most economical in fuel when developing all it will pull. The steam engineer, being used to putting more load on the steam engine than the rated capacity and having experienced no bad results from so doing, tries the same stunt on the oil engine, and this is where he falls down.

A few years ago another engineer and I visited a plant where two 500-hp. Diesels were being installed. This was a steam plant and had three Corliss engines operating. One was a 500-hp. cross-compound. The peak was on and this engine was carrying its steam valves. I called the other engineer's attention to it and made the remark, "A Diesel will never make good in this plant if they try such loads as that on them." Those engines, so I have been informed, have never made good there. I don't know why, but I will bet that the trouble is overload. The steam engineers will be the best Diesel operators if they look out for that overload.

I have never yet seen an internal-combustion engine that I thought should be operated at its rated capacity. I find about 90 per cent. load to be the best. Further, I always advise, "Keep them cool!" I know the expert will kick about "keeping them cool" and 90 per cent. load, and will cry, "Efficiency!" But efficiency cannot be bought with such expensive stuff as cylinder heads, pistons and cylinder liners, shutdowns, interrupted service, etc.

Mr. Weaver has explained that there is no comparison at all between a Diesel and a "flivver." I would ask, How many hours will a "flivver" engine run pulling its full rated capacity? My experience and observations teach me that a "flivver" engine seldom is run at 25 per cent. of its rated capacity on the average. I have never tried it out, but I believe that 24 hours' steady run at full rated capacity will put a "flivver" engine in the shop for repairs and that four or five minutes at full load seldom proves injurous unless it comes too often in one run. We will have to admit the "flivver" has about the simplest of power plants, but to make it simple, many other good points had to be sacrificed, such as we never would tolerate in a Diesel engine.

As for comparing a "flivver" operator with a Diesel operator, there is no comparison. One is a pedal pusher and the other is one who knows what takes place when the pedal is pushed; in other words, one does his work with his feet and the other does his work with his head, and of course the pedal pusher does considerable work on a cold morning with his good right arm.

The man who says a skilled mechanic is unnecessary for operating a Diesel is either kidding himself or has lots to learn about a Diesel. An Apache Indian can run a "flivver," but would you hire one to run a Diesel? The Diesel and several semi-Diesel engines are a success; that we know. In most cases where they fail it is a failure of the engineer and not the engine. Let us accept this engine as it is and not as a simple apparatus that anybody can operate. If we do this, we will learn a lot about them and make them successful. But don't overload them.

Winkelman, Ariz. GEORGE J. TROSPER.

Replacing a Boiler-Feed Valve

I have had considerable experience with low-pressure heating boilers, and my opinion is that it would be a much quicker job to draw the fire, blow off the boiler and attach a new cock, than it would be to do the vacuum trick, as described by Mr. Cooper on page 826 of the May 27 issue.

I recollect a case under somewhat similar conditions, but the operator did not attempt any vacuum stunt. He used his jack-knife to trim out a wooden plug. bored a hole through it and used this plug for several hours until he was ready to put in another cock. The water caused the plug to swell somewhat but not enough to prevent its being turned in the body of the cock to supply water to the boiler.

Kingston, Ont., Canada. JAMES E. NOBLE.

Better Cylinder-Oil Testing Methods

On page 327 of the Mar. 4 issue of *Power*, I made a statement as follows: "The proper place to test a cylinder oil is in the cylinder of the engine in which it is to be used." I did not give my reasons for holding this belief, but for the edification of Mr. Weaver, who, on page 740 of the May 13 issue, draws the inference that I would feel inclined to try any old oil on my best engines, although a thousand employees were dependent on that engine for power, I will endeavor to state them briefly and simply.

Any test of power-plant apparatus is always made on the apparatus itself under as nearly actual operating conditions as it is possible to attain. I refer to efficiency tests particularly, and a lubrication test, as I conceive it, would be a test of the efficiency of the lubricant used on a machine when it is under actual operating conditions.

A present-day definition of lubrication efficiency would probably be a maximum degree of perfection of lubrication at a minimum cost. There is no one oil that will satisfactorily lubricate all cylinders, because all cylinders are not alike, nor are they operated under identical conditions. We have many variables, among them weight of the piston, area swept over by the piston, steam pressure and temperature and work done by the piston. I would certainly hesitate to use an oil on a 100-hp. engine, under 180 lb. steam, solely because it had proved satisfactory on a 4 x 6-in. engine under 60-lb. steam, nor would I be so foolish as to experiment with "any old oil on an engine upon which one thousand employees were dependent for power."

An engineer, in selecting a cylinder oil, uses judgment, based largely upon his experiences, under as nearly similar conditions as he has had, or upon the recommendation of the builders of the engine, who, in turn, arrive at their conclusions by practically the same method as the engineer, the main difference being a larger fund of experience from which to draw. Engineers are well aware that the valves of an engine will begin to show signs of distress, generally a groan, upon lack of lubrication and, in order to forestall this condition, make sure that enough oil is being fed without being quite so sure that too much is not being fed, which, it should be remembered, has a decided influence on the efficiency.

I have never seen an instrument or a device that would indicate to the engineer a deficiency of oil in the cylinder, nor have I seen anything of this kind advertised. I know of but two methods of detecting lack of lubrication. One is the sign of distress, so easily recognized by most engineers; the other is an examination of the interior of the cylinder. In either case it to too late, as a certain amount of damage (however slight it may be) has already been done. What is wanted is some device that will tell when not enough oil is being fed to the cylinder at the time that the deficiency exists and not a few hours later.

I suggested using a two-pen recording thermometer, one pen attached to the cylinder head and one to the center of the cylinder wall, assuming that there would be a slight difference of temperature between the two points, also a variation of temperature, according to the steam pressure carried. It seems reasonable to me to assume that the head would be at a slightly higher temperature than that at the center of the cylinder wall. Should there be a difference in temperature and a variation of the steam pressure, then the variation of the two lines should follow each other closely. Should there be no variation of the steam pressure, then a variation of the other line, in an upward direction, would indicate a rise in temperature, due to some other cause, which I am assuming to be friction.

If, as Mr. Weaver suggests, the heat of friction is carried away as fast as generated, then, certainly, my idea will not work. If not, I can see no reason why it should not work. Mr. Weaver should read my letter again. I did not make any suggestion to cut the oil down until a rise in temperature was perceptible. I assure him that I attempt no such foolish stunts. With no attempt at irrelevance, I would like to ask Mr. Weaver where he tests his cylinder oils.

New York City. WILBERT WALTON CRANFORD.

The Art of Synchronizing

I have read the editorial, "The Art of Synchronizing" in the Apr. 29 issue, and find it very significant to the engineer who has alternating-current machinery to deal with.

When I was learning to be an operator, I was instructed to close the switch on the incoming unit, with the synchronoscope turning very slowly in the fast direction, when the pointer was on the mark. To do this the operator must take into consideration that the oil-switch mechanism takes a fraction of a second to act, and he must close the pilot switch before the indicator reaches the mark by a few degrees. If the operator closes the pilot switch on either motions of the synchronoscope, he is sure of making some poor throws. Our best operators always close the switch on the incoming machine with the needle turning in the fast direction.

I know of a belt-driven station that was furnishing two-phase power, in which there was only one operator that was able to synchronize without making the belts squeak so that they could be heard two blocks away. One Sunday the chief engineer decided to try to remedy the difficulty. The plant had been in operation for several months, and lamps were used for synchronizing. The chief changed the wires of the lamps to the opposite phase on one of the machines, then on synchronizing everything was found to be correct, the trouble having been due to the synchronizing lamps being connected to opposite phases on the two machines.

I always have synchronized on the bright light instead of the dark, but either method is correct if the objective is obtained. Today a station that does not employ a synchronizing instrument for paralleling alternating-current generators is lacking in up-to-date methods. It is also very desirable that the voltage of the two machines be the same, although some operators are not careful in this respect. We operate both reciprocating-engine- and turbine-driven units and invariably use the throttle valve during synchronizing, although we may equalize the load while in operation by the governor motor.

Knowing what causes the trouble after it is all over is worth while, but knowing how to avoid it is worth a whole lot more. I heartily agree with Mr. Gillooly's statement, in the same issue containing the editorial, that an operator must read more from the instrument than is printed on the dial. P. W. PETERS.

New York, N. Y.

Inquiries of General Interest

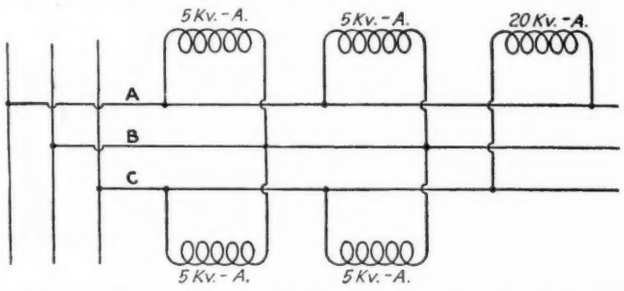
Use of Live-Steam Feed-Water Heater—What are the advantages of using a live-steam feed-water heater?

F. R.

Live-steam feed-water heaters are of advantage when the feed water can be purified by heating it to a high temperature and also in preventing stresses in a boiler due to use of cold feed water. But there is no gain in economy from heating the feed water with live steam, as the heat added to the feed water is taken from the boiler and there is a loss by radiation of heat from the heater and its connections.

Balanced Load on Three-Phase System—Will a load distributed as in the figure, give a balanced condition in the three-phase distribution system?

D. M. S.



The loading arrangement given in the diagram does not balance the three phases. There is 10 kv.-a. more load connected between *A* and *C* than there is between *A* and *B* or *B* and *C*. The total load on the system is 40 kv.-a. Then to divide this so as to put an equal load on each phase, ⅓ of 40, or 13⅓ kv.-a. will have to be connected between each pair of conductors. If the 20-kv.-a. load could be reduced to 10 kv.-a., this would balance the system against the 10 kv.-a. loads on each of the other two phases.

Muffler for Safety Valve—What means can be employed for silencing or deadening the noise of steam escaping from a high-pressure safety valve?

J. H. S.

The sharp noise arising from the blowing off of a safety valve can be quieted by discharging the steam through a muffler in which the steam passes through a number of compartments with staggered openings for breaking up the regularity of vibration and gradually reducing the velocity of the escaping steam. Pop valves with combined mufflers are made with means for adjusting the relief pressure and the amount of blowdown. When a separate muffler is used, the relieving and blowdown pressures of the safety valve must be adapted to the back pressure incident to employment of the muffler.

Boiler Pressure Required for Pumping—What boiler pressure would be required to operate a direct-acting steam pump having an 8-in. diameter steam cylinder and a 6-in. diameter water cylinder, for pumping water to a height of 100 ft. with the suction water supplied at a pressure of 10 lb. per sq. in.?

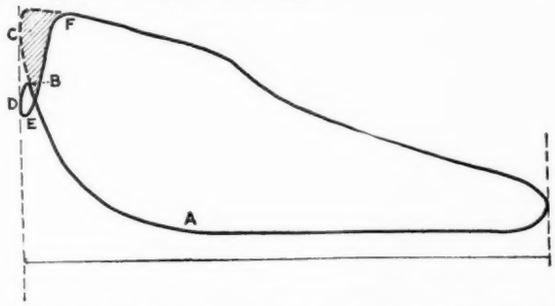
A. H.

The mechanical efficiency of a pump of the stated size, when in good working order, would be about 65 per cent. The pressure pumped against would be $100 \times 0.433 = 43.3$ lb. per sq. in. due to the head, plus the pressure required to overcome friction of the water in the discharge pipe, the latter depending on the rate of pumping and the diameter, length and fittings of the discharge pipe. Under ordinary conditions the loss of pressure from pipe friction would be no greater than 10 lb. per sq.in., and if assumed to be equal to the suction pressure, the net resistance to movement of the water piston would be $(6 \times 6 \times 0.7854) \times 43.3 = 1224$ lb. With 65 per cent. mechanical efficiency of the pump, the resistance to be overcome by the steam piston would be $1224 \div 0.65 = 1883$ lb., and for overcoming that resistance, the effective pressure required to be exerted on a direct-acting 8-in. diameter steam piston would be $1883 \div (8 \times 8 \times 0.7854) = 37.46$ lb. per sq.in. The required boiler pressure will need to be equal to the effective pressure, plus the back pressure and the reduction of the boiler pressure by throttling in the steam pipe and steam passages of the pump. Allowing a back pressure of 4 lb. and reduction by throttling of 10 lb. per sq.in. would require a boiler pressure of $37.46 + 4 + 10 = 51.46$, or about 52 lb. per square inch.

Engine Piston Over-riding Indicator Hole—If the piston of an engine travels over the hole in the cylinder for the indicator piping, how does it affect the diagram?

W. L. R.

When the piston over-rides the hole in the end of the cylinder for the indicator connection, communication is temporarily cut off between the interior of the engine cylinder and the indicator cylinder, and if there were no leakage past either the indicator piston or the engine piston, the pressure of steam would remain constant and a short straight line would be traced on the diagram from the point in the return stroke at which the engine piston covered the opening to the end of the stroke, and the line would be retraced until the piston uncovered the hole. But there is always free leakage past the indicator piston and generally past the engine piston. Hence, there usually is a small drop of pressure indicated until the engine piston has again uncovered the hole, when the indicator pencil immediately rises to the point correctly corresponding with the pressure in the engine cylinder, the drop and rise forming a loop at the end of the diagram.



A diagram with such a loop is shown by the full lines of the illustration. The indication of increase in compression of the exhaust from *A* toward the end of the stroke is arrested at *B* by the engine piston covering the indicator connection and falls to *D* at the end of the exhaust stroke, whereas the engine cylinder pressure continues to rise and should be indicated by continuing the compression line from *B* to *C*. The indicator pencil continues to fall from *D* to *E* in the beginning of the admission stroke and at *E* the hole is again uncovered and the pencil rises to *F* in response to pressure within the cylinder, but without embracing the shaded area *B C F*, which should have been included in the diagram.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Universal Craftsmen's Convention

THE seventeenth annual convention of the Universal Craftsmen Council of Engineers was held in Newark, N. J., during the week beginning Monday, Aug. 4, with headquarters at the Robert Treat Hotel.

The several sessions of the delegates were held in the McCarter Library, situated on the main floor of the hotel, and the grand ballroom adjoining was neatly decorated and conveniently arranged for the use of the exhibitors in the display of engine-room supplies and power-plant equipment. Fifty-six firms occupied booths, and there were 75 contributors, several of whom were denied display space owing to the lack of room. The display was generously patronized throughout the week.

There were present between ninety and one hundred delegates, representing nearly two hundred votes, and many prominent out-of-town members who came as visitors. The important business of the convention was carried on with harmony and dispatch, and many resolutions tending to the uplift and enlarging of the organization were discussed and passed upon. The members were gratified with the reading of the treasurer's report, which places the association on a solid financial basis. There is to be an earnest educational drive throughout the several councils the coming fall and winter, and arrangements will be made for the engagement of professors of engineering for the purpose of instruction on technical subjects and for the delivering of suitable lectures. It is the opinion of some of the earnest members that there has been in the recent past a slowing down of the educational features of the organization, and that never before in the history of engineering was there a greater need for study and advancement, more especially in the operating line.

The delegates and supplymen and ladies were liberal in their praise of the local committee. There was not a detail for the comfort of the visitors that was overlooked. The committee comprised William G. Warfield, chairman; Ellwood Homsher, vice chairman; Joseph Paton, secretary, and John MacMorran, treasurer.

The opening ceremonies of the convention took place on Tuesday morning. William G. Warfield occupied the chair and made a brief address of greeting to the delegates and visitors and introduced A. Archibald, director of finance of the City of Newark, who heartily welcomed the convention. Grand Worthy Chief Frank M. Townsend responded for the engineers. He congratulated the supplymen on the excellence of their display, and expressed the wish that the spare moments of the delegates would be spent in visiting the many booths and viewing the interesting exhibit, many items of which were new and instructive. William J. Brennan, commissioner of public works, told of the immense manufacturing interests of Newark and hoped that the visitors would find time to inspect some of its plants. Mayor Charles P. Gillen hoped that the company would excuse his tardiness and said that he had just stolen away from the temporary city markets where he had been busy for some days in the important business of selling bacon, eggs and other war foods to the people at reduced prices. He spoke of the rapid growth of Newark and said many other pleasant things to the audience, concluding by wishing them a pleasant and profitable stay, saying that the services of the officers of the entire city government were at the disposal of the convention. A telegram was read by Chairman Warfield from Thomas L. Raymond, commissioner of public works, expressing regrets for his absence and sending his best wishes. Mr. Warfield then formally opened the exhibition, which brought the ceremonies to a close.

On Tuesday evening a lecture was delivered by C. W. Obert, on the A. S. M. E. Boiler Code, which was largely attended and proved of special interest.

At the close of the Wednesday afternoon session the past grand worthy chiefs formed an association, to be composed of past chiefs only, for the purpose of boosting the organization in general. O. M. Pomeroy was elected president and Charles Siegrist secretary.

On Thursday afternoon there was a steamboat excursion to Coney Island, which included refreshments and a combination ticket to the features at Luna Park.

The memorial services were conducted by Chaplain P. H. Early on Friday afternoon to pay tribute to the memory of the 38 brothers of the local councils who have passed away at home and abroad during the past year.

On Friday evening a banquet was held at the Washington Restaurant at which short addresses were made by the Rev. A. B. Fitz-Gerald, Commissioner William J. Brennan and Past Worthy Chief Frank Townsend. An entertainment was given by the New York "Bunch," including W. C. Eagon, of the Dearborn Chemical Co.; Bob Jones, of the France Packing Co.; Billy Murray, of Jenkins Bros.; Monroe Silver, the National Male Quartette and Jack Armour, of *Power*. Frank Martin, of Jenkins Bros., had the entertainment in charge, and William G. Warfield was the toastmaster. Dancing concluded a good night's fun.

During the week the ladies were entertained with auto rides, theater parties and shopping trips.

The election of the grand officers resulted as follows: Frank Conroyd, worthy chief, Chicago, Ill.; Andrew Benner, assistant worthy chief, Cleveland, Ohio; Frank M. Townsend, past worthy chief, Grand Rapids, Mich.; Thomas H. Jones, secretary, Washington, D. C.; John L. O'Brien, treasurer, Chicago, Ill.; William G. Warfield, warden, Newark, N. J.; Henry W. Burton, guard, Cleveland, Ohio; P. H. Early, chaplain, Milwaukee, Wis.; trustees, James M. Patton, Buffalo, N. Y.; George G. Brown, Pittsburgh, Penn.; W. W. Law, Trenton, N. J.

Springfield, Mass.. was selected as the place for the next convention, which will be held in August, 1920.

DELEGATES, SUPPLYMEN AND VISITORS AT THE SEVENTEENTH ANNUAL CONVENTION OF THE

Physical Properties of Brines*

By E. F. MUELLER†

A CONSIDERABLE body of data is available relating to those physical properties of salt solutions which are of interest in refrigerating engineering, but it appears, because these data have not been assembled in a readily available form, that they have not been utilized as much as they might have been. An attempt will, therefore, be made to outline the manner in which the data may be tabulated.

The *specific gravity* of a brine is the ratio of the mass of unit volume of the brine at 60 deg. F. to the mass of unit volume of water at 39 deg. F.

The *concentration* of a brine is the number of pounds of (anhydrous) salt contained in one hundred pounds of brine.

The *specific heat* at any temperature is the number of British thermal units per degree required to raise the temperature of one pound (mass) of brine.

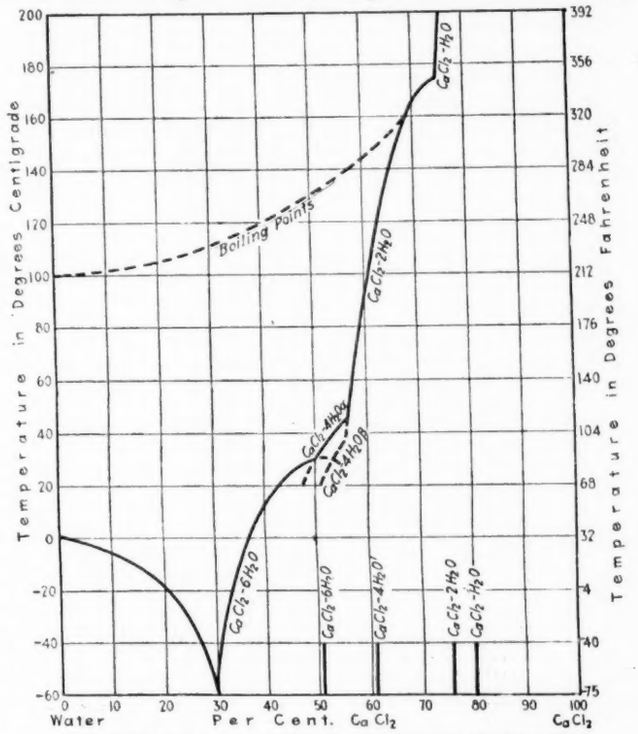
The *heat content* of a brine at any temperature is the number of B.t.u. which must be *absorbed* by one pound (mass) of the brine to change its temperature from 32 deg. F. to the temperature in question. The heat content will therefore be represented by negative numbers for temperatures below 32 deg. F.

The *B.t.u.* is here defined as the quantity of heat per degree required to raise the temperature of one pound (mass) of water at 60 deg. F.

The *freezing point* of a brine is the temperature at which crystals of ice first begin to separate out from the solution.

Solubility data for calcium chloride — The phenomena which occur on cooling a brine below its freezing point are perhaps of sufficient interest to warrant a digression from the main topic. In Fig. 1, which is taken from the Landolt-Bornstein-Roth Physical Chemical Tables, are shown the solubility data for calcium chloride in water. The ordinates represent temperatures and the abscissas the per cent. of salt in the solution. Thus any point at the left of the figure represents pure water (or ice) and any point at the right represents pure calcium chloride. The solid and broken curves represent conditions under which solutions and solids can exist in equilibrium, and the region above the curves represents conditions under which the solutions can exist. The upper dotted curve represents boiling points and, at atmospheric pressure, solutions cannot exist above this line; that is, solutions can exist only under the conditions of temperature and concentration defined by the region between the curves and the dotted line.

To illustrate, start with a 10 per cent. solution of calcium chloride at a temperature of, say, 20 deg. C. and cool it. The composition of course remains constant and a vertical line (falling temperature) is traced until the ice line is reached at a temperature of about —6 deg. At this point crystals of practically pure ice separate out (freezing point), consequently the concentration of the remaining solution increases in such manner that the ice line is traced with continuously decreasing temperature and continued



SOLUBILITY OF CALCIUM CHLORIDE IN WATER

separation of pure ice. When the solution has reached a concentration of about 29.9 per cent. the temperature will be —55 deg., the eutectic temperature. At this point another solid, the hexahydrate $CaCl_2 \cdot 6H_2O$, appears and the temperature of the remaining liquid cannot be lowered, since any further abstraction of heat merely results in separating out a mixture of ice and hexahydrate at constant temperature (—55 deg.), this mixture having the same composition as the liquid (eutectic composition). At the eutectic temperature the two solids and the solution (29.9 per cent.) can exist in equilibrium, and as long as the three are present the temperature remains fixed.

*Abstract of a paper before the Spring Meeting, American Society of Refrigerating Engineers, Cincinnati, O.

†Associate Physicist, National Bureau of Standards.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS AT NEWARK, NEW JERSEY, AUGUST 8 TO 12

If, instead of starting with a 10 per cent. solution, a 20 per cent. solution had been taken, the ice line would have been reached at a temperature of about —18 deg., after which the ice line would have been traced as before. On heating, the phenomena described would occur in reverse order.

If, instead of a 10 or 20 per cent. solution, a 40 per cent. solution had been taken, the phenomena would have been different. At about +12 deg. the hexahydrate line is reached and at this point the hexahydrate, which, as indicated in the lower part of the figure, consists of about 51 per cent. of salt, separates (freezes) out or, rather, crystallizes, the concentration of the solution decreases and the hexahydrate line is traced until the eutectic point at —55 deg. is again reached, at which point the mixture of ice and hexahydrate separates out as before. By starting with larger concentrations other parts of the curves may be traced. However, it can be seen from the figure that solutions more concentrated than about 69 per cent. cannot exist at atmospheric pressure, because the water would boil off. Starting, however, with a 60 per cent. solution at a temperature of 130 deg., on cooling the solution the dihydrate line is reached at a temperature of about 87 deg., the dihydrate begins to separate out and the dihydrate line is traced until it intersects the tetrahydrate line at about 45 deg. At this point, which is a transition point, the two hydrates and the solution (57 per cent.) can exist in equilibrium, and as long as the three are present the temperature remains fixed. If heat is abstracted from the mixture, more of the tetrahydrate crystallizes out and some of the dihydrate takes up the surplus water and is transformed into the tetrahydrate. This transition point is, therefore, markedly different from the eutectic, since at the eutectic the one solid form does not change into the other.

It will be noted that the tetrahydrate contains 61 per cent. of $CaCl_2$, consequently, if the solution had contained originally more than 61 per cent. of $CaCl_2$, the transition to the tetrahydrate could not have been completed. Having started with a 60 per cent. solution, however, the transition may be supposed to be completed, after which the tetrahydrate line would be traced down to the next transition point.

The above represents only a part of what can be read from such a diagram as Fig. 1, and the actual phenomena are by no means as simple as indicated in this rapid description. For example, the broken lines represent unstable equilibria of somewhat the same character as the well-known subcooling of water below its freezing point. It may also be seen that the so-called fused calcium chloride, containing 75 per cent. of calcium chloride, corresponds in composition to the dihydrate, and that that latter can be obtained by evaporating a solution to dryness at atmospheric pressure and a temperature of about 166 deg.

TABLE I—HEAT CONTENT IN B.T.U. PER POUND (MASS) OF CALCIUM CHLORIDE BRINES OF SEVERAL SPECIFIC GRAVITIES

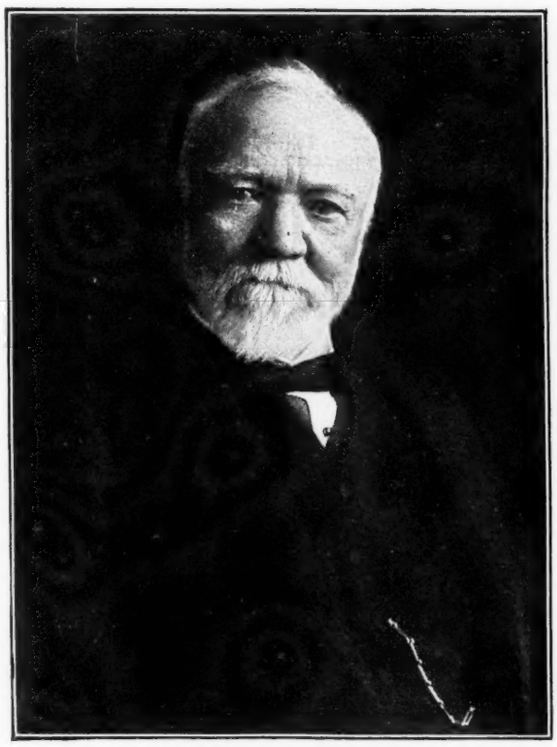
Temp. Deg. F.	Specific Gravity (60 to 39 Deg.) 0.999	1.05	1.10	1.15	1.18	1.20	1.22	1.24	1.26	1.28
—20	.....	.....	.....	.....	.....	.....	.....	—34.82	—34.00	—33.41
—19	.....	.....	.....	.....	.....	.....	.....	—34.16	—33.42	—32.78
—18	.....	.....	.....	.....	.....	.....	—34.28	—33.50	—33.77	—32.14
—17	.....	.....	.....	.....	.....	.....	—33.61	—32.84	—32.13	—31.51
—16	.....	.....	.....	.....	.....	.....	—32.93	—32.18	—31.24	—30.87
—15	.....	.....	.....	.....	.....	.....	—32.25	—31.52	—30.88	—30.24
—14	.....	.....	.....	.....	.....	.....	—31.58	—30.86	—30.18	—29.60
—13	.....	.....	.....	.....	.....	.....	—28.96	—30.90	—30.19	—28.96
—12	.....	.....	.....	.....	.....	.....	—30.22	—29.53	—28.88	—28.33
—11	.....	.....	.....	.....	.....	.....	—29.54	—28.86	—28.28	—27.60
—10	.....	.....	.....	.....	.....	.....	—28.86	—28.20	—27.50	—27.05
— 9	.....	.....	.....	.....	.....	.....	—28.18	—27.54	—26.94	—26.41
— 8	.....	.....	.....	.....	.....	—28.21	—27.50	—26.87	—26.28	—25.78
— 7	.....	.....	.....	.....	.....	—27.51	—26.82	—26.21	—25.63	—25.14
— 6	.....	.....	.....	.....	.....	—26.82	—26.14	—25.54	—24.98	—24.50
— 5	.....	.....	.....	.....	.....	—26.12	—25.46	—24.88	—24.33	—23.86
— 4	.....	.....	.....	.....	.....	—25.42	—24.78	—24.24	—23.68	—23.22
— 3	.....	.....	.....	.....	.....	—24.72	—24.01	—23.54	—23.03	—22.53
— 2	.....	.....	.....	.....	—24.66	—24.02	—23.42	—22.88	—22.38	—21.94
— 1	.....	.....	.....	.....	—23.94	—23.32	—22.74	—22.21	—21.72	—21.30
0	.....	.....	.....	.....	—23.22	—22.62	—22.05	—21.54	—21.07	—20.66
1	.....	.....	.....	.....	—22.50	—21.92	—21.37	—20.88	—20.42	—20.02
2	.....	.....	.....	.....	—21.78	—21.22	—20.69	—20.21	—19.76	—19.38
3	.....	.....	.....	.....	—21.06	—20.52	—20.00	—19.54	—19.11	—18.74
4	.....	.....	.....	.....	—20.34	—19.82	—19.32	—18.87	—18.46	—18.10
5	.....	.....	.....	.....	—19.62	—19.12	—18.63	—18.20	—17.80	—17.46
6	.....	.....	.....	.....	—18.90	—18.41	—17.95	—17.53	—17.15	—16.81
7	.....	.....	.....	.....	—18.18	—17.71	—17.26	—16.86	—16.49	—16.17
8	.....	.....	.....	—18.21	—17.45	—17.01	—16.58	—16.19	—15.84	—15.53
9	.....	.....	.....	—17.46	—16.73	—16.30	—15.89	—15.52	—15.18	—14.88
10	.....	.....	.....	—16.70	—16.01	—15.60	—15.20	—14.85	—14.52	—14.24
11	.....	.....	.....	—15.95	—15.28	—14.89	—14.52	—14.18	—13.87	—13.60
12	.....	.....	.....	—15.19	—14.56	—14.19	—13.83	—13.51	—13.21	—12.95
13	.....	.....	.....	—14.44	—13.84	—13.48	—13.14	—12.83	—12.55	—12.31
14	.....	.....	.....	— 13.68	—13.11	—12.78	—12.45	—12.16	—11.90	—11.66
15	.....	.....	.....	—12.93	—12.39	—12.07	—11.76	—11.49	—11.24	—11.02
16	.....	.....	.....	—12.17	—11.66	—11.36	—11.08	—10.82	—10.58	—10.37
17	.....	.....	.....	—11.41	—10.94	—10.66	—10.38	—10.14	— 9.92	— 9.73
18	.....	.....	.....	—10.65	—10.21	— 9.95	— 9.70	— 9.47	— 9.26	— 9.08
19	.....	.....	.....	— 9.89	— 9.48	— 9.24	— 9.01	— 8.80	— 8.60	— 8.43
20	.....	.....	.....	— 9.14	— 8.76	— 8.53	— 8.32	— 8.12	— 7.94	— 7.79
21	.....	.....	— 9.11	— 8.38	— 8.03	— 7.80	— 7.62	— 7.44	— 7.28	— 7.14
22	.....	.....	— 8.28	— 7.62	— 7.30	— 7.11	— 6.93	— 6.77	— 6.62	— 6.49
23	.....	.....	— 7.46	— 6.86	— 6.57	— 6.40	— 6.24	— 6.09	— 5.96	— 5.84
24	.....	.....	— 6.63	— 6.10	— 5.84	— 5.69	— 5.55	— 5.42	— 5.30	— 5.20
25	.....	.....	— 5.80	— 5.34	— 5.12	— 4.98	— 4.86	— 4.74	— 4.64	— 4.55
26	.....	.....	— 4.98	— 4.57	— 4.38	— 4.27	— 4.16	— 4.07	— 3.98	— 3.90
27	.....	.....	— 4.15	— 3.81	— 3.65	— 3.56	— 3.47	— 3.39	— 3.32	— 3.25
28	.....	.....	— 3.32	— 3.05	— 2.92	— 2.85	— 2.78	— 2.71	— 2.65	— 2.60
29	.....	.....	— 2.74	— 2.49	— 2.19	— 2.14	— 2.08	— 2.03	— 1.99	— 1.95
30	.....	— 1.83	— 1.66	— 1.53	— 1.46	— 1.43	— 1.39	— 1.36	— 1.33	— 1.30
31	.....	— .91	— .83	— .76	— .73	— .71	— .70	— .68	— .66	— .65
32	0.00	0	0	0	0	0	0	0	0	0
35	3.02	2.74	2.49	2.29	2.20	2.14	2.09	2.04	1.99	1.95
40	8.05	7.30	6.65	6.12	5.87	5.72	5.57	5.44	5.32	5.22
45	13.07	11.87	10.82	9.96	9.55	9.30	9.07	8.86	8.66	8.49
50	18.08	16.44	15.00	13.81	13.24	12.90	12.57	12.28	12.01	11.77
55	23.08	21.02	19.18	17.67	16.94	16.50	16.09	15.72	15.37	15.06
60	23.08	25.60	23.38	21.54	20.65	20.12	19.61	19.16	18.73	18.36
65	33.07	30.18	27.58	25.42	24.37	23.74	23.14	22.61	22.11	21.67
70	38.06	34.77	31.78	29.30	28.10	27.37	26.69	26.07	25.50	24.99

Andrew Carnegie

In the quiet of his Berkshire home, in the 84th year of his age, Andrew Carnegie passed away on Monday of last week. If it had not been for the steam engine, he might have passed away at Dumferline, Scotland, leaving a little weave shop instead of a colossal fortune.

He was a conspicuous example of the success which comes from apparent misfortune, of achievement inspired and induced by hard knocks. His father was a hand weaver in Dumferline, with four damask looms and a number of apprentices. The business was made unprofitable by the coming in of the factory system, and the family came to America in 1848, father and mother, Andy, 13, and Tom, 6 years old, and settled down in Barefoot Square, Slabtown, Penn.—about as discouraging a beginning as the fates could have laid out.

Although his career was that of the ironmaster and financier, he was tied into the field in which *Power* is interested in many ways. Almost the first employment which he found in the country of his adoption was that of fireman in the factory where his father worked at his trade and where the boy served a short term as bobbin boy at $1.20 a week. In later life he wrote a biography of James Watt. In 1851, at the age of 16, he became a messenger boy for the Ohio Telegraph Co., learned to use the instruments and became an operator for the Pennsylvania Railroad. A wreck occurring in the absence of Thomas A. Scott, the division superintendent, young Carnegie took it upon himself to send out telegrams with the superintendent's signature, holding trains and straightening out the tangle so cleverly that Mr. Scott made him his secretary and assisted him in making his first investments. When his patron was made Secretary of War, Carnegie was made superintendent of military railways and government telegraph lines in the East. Returning with his chief to Pittsburgh in 1862, fortunate investments, principally in oil lands, brought him returns which made him a real capitalist.



ANDREW CARNEGIE

He organized the Keystone Bridge Works for building bridges of iron instead of wood; and later the Union Iron Mills. While on a visit to England in 1868, he learned of the new bessemer steel process and returned to America bent upon its exploitation. This led to his becoming the principal owner of the plant at Braddock, Penn., and he soon absorbed the Homestead establishment across the Monongahela. This commenced the formation of the Carnegie interests, which subsequently netted him $250,000,000. Out of the wealth thus acquired liberal donations have been made for various purposes, those most intimately interesting our readers being the Carnegie Institute at Pittsburgh, the Carnegie Institution at Washington, a day school of mechanical arts at Cooper Union, the Engineers' Club of New York and the United Engineering Societies Building, which houses the great national engineering societies. Mr. Carnegie donated a million and a half for the two latter buildings on condition that the club and societies purchase the land. This was done and the buildings were completed in 1907. Of these he took a special interest in the American Society of Mechanical Engineers, in the Year Book of which his name appears as an honorary member with the simple designation, "philanthropist."

American Electrochemical Society's Fall Meeting

The American Electrochemical Society will hold its fall meeting in Chicago, Ill., Sept. 23-26, with headquarters at the Congress Hotel. A tentative program has been arranged and calls for four joint sessions with the American Institute of Mining and Metallurgical Engineers, which will hold its convention at the same time and place. The program as now arranged is as follows:

Tuesday, Sept. 23—Excursion by boat with American Institute of Mining and Metallurgical Engineers to Gary, Ind., and trip through the United States Steel Corporation's plant. Joint technical session, on the boat, returning from Gary, subject: Electrometallurgy of Iron and Steel. Joint technical session, at Congress Hotel at 8: 30 p.m.

Wednesday, Sept. 24—Morning, session for reading and discussion of papers; afternoon, joint, Ferrous Metals; evening, inspection of the electric furnace exhibits at the Chemical Exposition.

Thursday, Sept. 25—Morning and afternoon, Symposium of Catalysis; evening, smoker and entertainment.

Friday, Sept. 26—Morning and afternoon, joint session; subject, Symposium on Pyrometry.

The secretary of the society is Prof. Joseph W. Richards, Lehigh University, Bethlehem, Penn.

A. I. E. E. and N. E. L. A. Committee on Power Factor in Polyphase Circuits

A recent issue of the N. E. L. A. *Bulletin* announces the formation of a special joint committee on the determination of power factor in polyphase circuits, by the American Institute of Electrical Engineers and the National Electric Light Association. The present personnel of the committee is as follows: R. J. McClelland, chairman; Farley Osgood, vice chairman; S. G. Rhodes, secretary; Dr. P. G. Agnew, Frank Conrad, F. P. Cox, F. C. Holtz, Dr. A. E. Kennelly, E. W. Lloyd, G. A. Sawin, R. F. Schuchardt. It is the intention to report to the A. I. E. E. and the N. E. L. A. at the annual conventions next summer. The committee's plans are as follows:

1. To establish the purpose to be fulfilled by the use of the function known as "Power Factor," in the commercial, engineering and scientific aspects of the electrical art.

2. To establish a definition of the function which will definitely and correctly express this purpose, and will be suitable for scientific, legal and commercial use. A definite recommendation for such a definition will be offered.

1. To study and offer suggestions as to methods of measurement of power factor and to point out the applicability and limits of error of various methods of measurement.

4. Possibly to study and offer suggestions as to various methods of providing for power factor in contracts and rates.

The committee invites and hopes to receive suggestions and expressions of opinion, as well as statements of experience as to commercial application of power factor measurements.

Boston Engineers and Firemen Receive Increased Wages

Municipal stationary and marine engineers, firemen and oilers at Boston, Mass., were granted increased wages by Mayor Peters at a conference on Aug. 6, upon the ground that the previous rates of pay were below those prevailing in commercial establishments in the Boston district. A strike was threatened which might have resulted in serious interruptions in service in the sewage-pumping plants, ferries and public buildings of the city. Mayor Peters cut short his vacation and hastened to Boston to discuss the situation with the representatives of the engineers and firemen involved, and the result was a general standardization of pay corresponding to outside scales. The following rates have been established:

	Per Week
Operating engineers at pumping stations	$37
Marine engineers on city ferries	42
Engineers in charge, public buildings, first-class plants	42
Engineers operating public buildings, first-class plants	37
Engineers in charge, second-class plants	37
Engineers operating second-class plants	33
Engineers in charge, third-class plants	33
Engineers operating third class plants	30

Firemen and oilers in all plants, $5 per day.

In announcing these rates, Mayor Peters stated that the demands of the engineers, firemen and oilers for increased wages were originally received by him in June and that since that time he has been undertaking an extensive investigation into every phase of the situation. The mayor said:

It has become apparent to me that the work of this class of employees is just as arduous and exacting as that of similar employees of public-service corporations and individual firms in the city and in this respect lacks the advantages and privileges that go with many of the other classes of employment in the city service. As these men are working under conditions that are the same as in outside employment, they are entitled to the prevailing rate of wages established for that class of work.

It should be borne in mind that most of the men affected by this change in the wage scale work the full six days a week and are thus denied the privilege of a Saturday half-holiday enjoyed by a large number of other employees, while the important character of the service rendered by them in hospitals, institutions, pumping stations and ferries was another factor in their favor. In short, their situation was an isolated one and distinctly different from that of other classes of city employees.

Under the new wage scale engineers, firemen and oilers will be required to work the full six days of eight hours each, or 48 hours per week, and this arrangement was quite agreeable to the representatives of the union who called upon me. Because of the change in the wage scale of the engineers, etc., on the ferryboats, it will be necessary to readjust the salaries of the captains and quartermasters on these boats. Appropriate changes will be made when the other changes go into effect.

Michigan Section, N. E. L. A. Changes Dates for Conventions

At the Hotel Ottawa, Ottawa Beach, Mich., the Michigan Section of the National Electric Light Association will hold its convention Aug. 26 to 28. The date is one week later than that originally planned. The program as arranged includes six sessions, as follows:

Aug. 26, Morning Session—Address by President Thomas Chandler; address, "New Public Utilities Bill," by James V. Oxtoby; paper, "More Favorable Policy Toward Consumers," by John Swanson; paper, "The Central Station and the Contractor-Dealer," by R. A. Gordon.

Aug. 26, Afternoon Session—Paper, "Commercial Lighting," by J. F. Mayo; paper, "Practical Phases of Industrial Lighting," by H. H. Magdsick.

Aug. 26, Special Evening Session—Paper, "Safety," by Harry Burton; "The Queen of the Waves," two-reel educational film showing progress of electricity in navigation; illustrated talk by W. A. Durgin, on "Industrial Illumination."

Aug. 27, Morning Session—Paper, "Appliance Sales in the Detroit Edison Company's Suburban Districts," by A. H. Touscany; paper, "Electrical Merchandising," by H. H. Koelbel; paper, "Domestic Refrigeration," by E. J. Copeland; paper, "Electric Ranges, Their Sale and Operation," by R. F. Hotton.

Aug. 27, Dinner—Address, "Municipal Ownership," by F. G. R. Gordon, entertainment as arranged by the committee.

Aug. 28, Morning Session—Paper, "Insurance," by J. H. Lobban; paper, by J. A. Cavanaugh.

Correction of Error in 1918 Edition of National Electrical Code

In the 1915 edition of the National Electrical Code the second paragraph of Rule 23, section "a" reads as follows:

Where the switch required by No. 24 "a" is inside the building, the cutout required by this section must be placed so as to protect it, unless the switch is of the knife-blade type and is inclosed in an approved box or cabinet, under which conditions the switch may be placed between the source of the supply and the cutout.

Through an error this section was omitted when the 1918 edition was printed. The Electrical Committee of the National Fire Protection Association has voted that this matter be given the widest publicity, that all interested parties may be advised that this section was omitted. The Electrical Committee would recommend that the Inspection Departments approve an installation in accordance with this paragraph.

New Publications

AIRPLANE DESIGN AND CONSTRUCTION. By Ottorino Pomilio, Consulting Aëronautical Engineer for the Pomilio Brothers Corporation. Published by the McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City; Hill Publishing Co., Ltd., 6-8 Bouverie St., E. C., London. Cloth, 6 x 9 in., 403 pages; numerous illustrations and diagrams.

The reputation of the Pomilio Brothers Corporation as airplane designers and constructors is so well established that a treatise by their consulting engineer should take rank as an authority on airplane construction. In this volume the subject is divided into four parts, the first three being included under the general heading, "Structure of the Airplane," and the remaining one under "Design of the Airplane." The text is so arranged that it can be adapted to either elementary or advanced college courses in airplane design. For the airplane engineer the fourth part, on design, should prove a valuable reference and time-saver, as it is replete with tables and diagrams. Unfortunately, the space devoted to the very important subject of testing is far too brief. It seems a pity that Mr. Pomilio could not have secured as a collaborator some one of our engineers who is used to technical writing, as in some places the literal translations of Italian technical descriptions make rather unusual and even ambiguous English.

Personals

O. P. Hood is Acting Director of the Bureau of Mines in the absence of Van H. Manning, who is visiting the various experiment and rescue stations of the Bureau.

C. R. Matheny, sales manager of the Republic Flow Meter Co., called upon us on his way to Pittsburgh, where he is to open an office for his company about October first.

Professor Auguste C. E. Rateau, of Paris, France, has been granted the gold medal of the British Society of Mining Engineers, an additional new distinction conferred on the professor.

J. L. Canby has been appointed district manager of sales at Chicago for the Chicago Pneumatic Tool Co., succeeding Nelson B. Gatch, who has been transferred to the New York office as district manager of sales.

Business Items

The Green Engineering Co., East Chicago, Ind., announces the appointment of the firm of Bull & Livensparger as its sales representatives in Chicago and northern Illinois territory. E. H. Bull has been connected with the company as an engineer for the last seven years and D. A. Livensparger has been a member of the sales force for nine years. Their offices will be at 14 E. Jackson Boulevard, Chicago.

Trade Catalogs

The Mesta Machine Co., Pittsburgh, Penn., has recently issued a 127-page general catalog, bound in cloth and richly printed and illustrated. It gives a brief illustrated description of the plant and product of the company. The plant, which covers twenty acres, and equipment are so arranged that all machinery is built complete within the plant from the raw materials. This company builds a more complete line of heavy machinery for iron and steel works than any other company in the United States. The catalog is printed in French as well as in English.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F. o. b. mines, net tons	$2.60@3.10	$3.00@3.60
F. o. b. Philadelphia, gross tons	4.79@5.35	5.20@5.80
F. o. b. New York, gross tons	5.10@5.70	5.50@6.20
Alongside Boston (water coal), gross tons	6.85@7.35	7.10@7.85

Georges Creek is quoted at $3.70 per net ton, f. o. b. mines.

Pocahontas and New River are being quoted at $6.25@6.50 per gross ton f.o.b. Norfolk and Newport News, Va., in response to export demand. There are practically no sales for coastwise shipment.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Tidewater		Mine	Tidewater
Broken	$5.95	$7.80	Pea	$5.20	$6.95
Egg	6.25	8.10	Buckwheat	3.40	5.15
Stove	6.50	8.35	Rice	2.75	4.50
Chestnut	6.60	8.45	Barley	2.25	4.00

Bituminous

Current quotations on spot coal, net tons, at the mines average about as follows:

	Spot
South Fork (best)	$3.15@3.35
Cambria (best)	2.95@3.10
Cambria (ordinary)	2.75@2.95
Clearfield (best)	2.95@3.10
Clearfield (medium)	2.75@2.95
Clearfield (poor)	2.50@2.75
Reynoldsville	2.70@2.90
Quemahoning	3.10@3.25
Somerset (best)	2.95@3.10
Somerset (poor)	2.50@2.75
Western Maryland	2.50@2.75
Fairmont	2.10@2.35
Latrobe	2.60@2.65
Greensburg	2.50@2.60
Westmoreland ¾ in.	2.75@2.90
Westmoreland run-of-mine	2.50@2.60

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Anthracite Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.25	8.10	Rice	2.75	3.65
Stove	6.50	8.35	Boiler	2.50	3.50
Nut	6.60	8.45	Barley	2.25	3.15
Pea	5.20	6.80			

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.40@ 1.60	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton		Standard
Prepared sizes (lump, egg, nut, etc.)	$2.85*@3.05	$2.55	$2.25@2.50
Mine run	2.10*@2.35	2.35	1.60@1.70
Screenings	1.50*@2.20	2.05	.90@1.00

* Indicates prices on independent coal.

Williamson-Franklin rate to St. Louis is $1.07½; other rates $0.92½.

New Construction

PROPOSED WORK

Mass., Williamstown—The J. S. Boyd Co. is having plans prepared by Edmund F. Saxton, Cons. Eng., Tremont Bldg., Boston, for water power development, here.

N. Y., Amsterdam—The Consolidated Creamery Co., Fultonville, will receive bids for replacing engine, boiler and transmission and milk handling equipment which was recently destroyed by fire, with a loss of $100,000.

N. Y., Buffalo—The Pierce-Arrow Motor Co., 1695 Elmwood Ave., plans to build a 2 story addition to its boiler house at 1695 Elmwood Ave. Estimated cost, $100,000.

N. Y., Central Islip—The State Hospital Commission, Capitol, Albany, received bids July 29 for installing at the State Hospital, here, stokers, etc., in new central heating and lighting plant, from Chute. Thorton & Bailey Corporation, 2 East 13th St., New York City, $81,600; W. B. Armstrong Co., 3 Fulton St., Albany, $82,341; John W. Danforth Co., 70 Ellicott Sq., Buffalo, $82,993.

N. Y., Copenhagen—C. W. Pratt, of Island Paper Co., Tannery Island, Carthage, has purchased the High Falls hydro-electric development, here, and plans to double present 1000 hp. installation by building reinforced concrete addition to plant and new 1000 hp. generating unit. Estimated cost, $25,000.

N. Y., Hobart—The Board of Education of the Union Free School, District No. 4, Stamford Twp., will receive bids until August 23 for the construction of a 2 story, 36 x 100 ft., school. A steam heating system will be installed in same. Total estimated cost, $300,000. Rasmussen & Wegland, 1133 Broadway, New York City, Arch.

N. Y., Malone—The State Armory Bd., Capitol, Albany, received bids July 17 for installing heating system in the proposed addition to the armory, here, from Ryan Plumbing & Heating Co., Inc., Smith St., Watertown, $5,417; Thomas Breen Co., 414 Lafayette St., Utica, $5496; Adams, Britz & Co., Inc., 1761 Park Ave., New York City, $5668.

N. Y., Ripley—The Ripley Milk Products Co., plans to construct a cheese and butter plant and pasteurizing station. Company will install engine, boiler, ammonia system and milk handling machinery. Total estimated cost, between $60,000 and $75,000. C. B. Newbury, Pres.

N. Y., Rochester—Lesser Paley, Chn. of the Building Committee for the Rochester Jewish Home for the Aged, plans to install a steam heating system, elevator, etc., in the Wagner Memorial College on Oregon St. Estimated cost, $40,000.

N. Y., Syracuse—The American Agricultural Chemical Co., 92 State St., Boston, Mass., has acquired a site on the Barge Canal and Hiawatha St. and will erect a 3 story, 180 x 340 ft. warehouse, including 2 railroad sidings, concrete unloading pier with overhead unloader and conveyor system and overhead trestle with electric hauling units. Total estimated cost, between $300,000 and $500,000.

N. Y., Thiels—F. A. Vanderlip, Pres. Bd. Mgrs., Letchworth Village, 7 Wall St., New York City, received bids for installing heating system in the eight 1 story, 34 x 150 ft., steel cottages, here, from John C. Williams, Inc., 233 Broadway, $163,741; Adams, Britz & Co., Inc., 1761 Park Ave., $167,000; Lord Construction Co., 105 West 40th St., $168,500; contractors all of New York City.

N. Y., Utica—The State Hospital Commission, Capitol, Albany, received bids for installing a heating system in the buildings for Chronic Patients, at the Utica State Hospital, from the Globe Automatic Sprinkler Co., Cahill Bldg., Syracuse, $88,600; John W. Danforth Co., 70 Ellicott Sq., Buffalo, $92,590; H. C. Peterson Co., Inc., 20 Oneida St., $93,925.

N. Y., Watertown—Kops Brothers have acquired the plant of J. B. Wise, Inc., on Water St., and plan to install new machinery and transmission equipment for their own use. Total estimated cost, between $30,000 and $35,000.

N. J., Newark—The Board of Freeholders of Essex County received lowest bid for installing a heating and piping system in the proposed new sanitarium from Gillis & Geoghegan, 537 West Broadway, New York City, at $59,500.

Penn., Philadelphia—J. Miller & Sons Co., 16th and Reed St. is receiving bids for the construction of a 3 and 5 story, 98 x 118 ft. factory. A steam heating system will be installed in same. F. E. Hahn, 1112 Chestnut St., Arch.

Penn., Pittsburgh—The Atlantic Refining Co., Chamber of Commerce Bldg., will construct a 1 story, 45 x 125 ft. boiler house on 57th and Butler St. Estimated cost, $25,000.

Penn., Pittsburgh—The Board of Education, Fulton Bldg., plans to construct a 3 story, 170 x 303 ft. high school in Sheridan District. A boiler room, steam heating and ventilating systems and high pressure boilers will be installed in same. Total estimated cost, $664,500. McClure & Spahr, Keystone Bldg., Arch.

Penn., Pittsburgh—The Board of Education, Fulton Bldg., is having plans prepared for the construction of a 3 story, 130 x 242 ft. school on Perryville Ave., to to be known as Perry Elementary School. Steam heating and ventilating systems and low pressure boilers will be installed in same. Total estimated cost, $612,000. R. Kiehnell & Elliott, 245 4th Ave., Arch.

Penn., Pittsburgh—The Board of Education, Fulton Bldg., is having plans prepared for the construction of a 3 story, 75 x 340 ft. school on Greenfield Ave., to be known as Greenfield Elementary School, to include a boiler room, low pressure boilers and steam heating and ventilating systems. Total estimated cost, $598,720. Kiehnell & Elliott, 245 4th Ave., Arch.

Penn., Pittsburgh—The Board of Education, Fulton Bldg., plans to build a 3 story, 70 x 320 ft. school, to be known as Beechwood-Beechwood Elementary School. Steam heating and ventilating systems and low pressure boilers will be installed in same. Total estimated cost, $553,040. Press C. Boiler, Magee Bldg., Arch.

Ohio, Ashtabula—The city will receive bids until September 10 for installing a 1000 K.W. generator and equipment in the electric-light plant. Estimated cost, $50,000. Morris-Knowles, Jones Law Bldg., Pittsburgh, Penn., Engr.

Ohio, Madison—The city has retained W. J. Sherman, Engr., 613 Nasby Bldg., Toledo, to prepare plans for new water supply system and electric-light and power plants.

Ohio, Newark—Warren S. Weiant & Son have had plans prepared for a 3 story, 49 x 66 ft., power plant. Boiler-room equipment and coal bunkers will be installed in same. Bodenstein & Surmann, 405 Second National Bank Bldg., Cincinnati, Engr.

Ohio, Oxford—The village has sold its electric-light plant and will use proceeds, amounting to $35,000, to improve the waterworks, including new electric pumping equipment, new service mains, etc.

Ohio, Ravenna—The New Cascade Tire & Rubber Co. plans to build a 2 story tire plant here. A steam heating system will be installed in same. Total estimated cost, $1,000,000. Osborn Engineering Co., 2848 Prospect Ave., Cleveland, Engr.

Mich., Detroit—The Department of Purchases & Supplies, Municipal Courts Bldg., will soon award the contract for furnishing 4 gasoline driven double diaphram trench pumps with 3 in. suction and discharge hose, mounted on wheels; also 4 trench backfillers, equipped with one-man scraper, gasoline engines and caterpillar traction. Address J. A. Martin.

Mich., Detroit—The Masonic Athletic Association, c/o G. W. Graves, Arch., 43 John R. St., is having plans prepared for a 3 story, clubhouse on the shore of Lake St. Clair. A steam heating system will be installed in same. Total estimated cost, $100,000.

Mich., Port Huron—The Holmes Foundry Co. plans to install a fire protection system, including a 1000 gal. per minute centrifugal pump, 100 lb. pressure, with 100 H.P. 200 volt direct current motor, automatic starter, compensator and all necessary wiring, about one mile of extra heavy 10 in. cast iron pipe and 800 ft. of 8 in. pipe, all laid on concrete base; also pump house, intake, well and cribbing at foot of Connor St. on the St. Clair River. Estimated cost, $31,000.

Minn., Foley—The city is having plans prepared for the construction of waterworks and sewerage systems, including 60,000 gal., steel tank pump and 1000 gal per minute motor. Estimated cost, $40,000. Chute & Bradley, St. Cloud, Engrs.

Neb., Broken Bow—The Custer Electric Co. is in the market for a 125 or 150 h.p. Corliss engine, direct or belted.

Mo., Duenweg—The M. & T. Mining Co. plans to move its mill from Granby District and erect same here, and is in the market for boiler, steam engine, compressor and rolls. R. McGee, Gen. Mgr.

Mo., Excelsior Springs—The Masonic Building & Realty Co. plans to build a 3 story temple. A steam heating system will be installed in same. Total estimated cost, $100,000. Owen & Payson, Kansas City, Mo., Arch.

Mo., St. Joseph—Buchannan County is having plans prepared for the construction of a 2 story infirmary. A steam heating system will be installed in same. Total cost, $235,000. R. Meier, W. Boschers and R. Arnold, Arch.

Okla., Guthrie—The Scottish Rite Consistory plans to construct a consistory building. Total estimated cost, $500,000. Hawk & Pain, Oklahoma, Arch.

Wash., Everett—The city is having preliminary plans prepared for developing 5000 to 6000 hp. electric power water plant; work involves enlargement of present dam, constructing new dam and building tunnel through rock walls. Water is to be taken from Sultan River. Estimated cost, $10,000.

Cal., Pasedena—S. B. Morris, Ch. Engr., City Water Dept., has recommended that city construct distributing system in San Rafael Heights, to cost $100,000, a reservoir at about $17,000, also the installation of a booster pump.

Ont., Brantford—The Cockshutt Plow Co. plans to build a 1 story, 50 x 60 ft. and a 4 story, 100 x 145 ft. addition to its plow factory. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ont., London — The Greene Swift Co., will soon award the contract for the construction of a 4 story, 40 x 100 ft. factory addition on Talbot St. An engine and boiler will be installed in same. Total estimated cost, $50,000. W. S. Murray, Dominion Savings Bldg., Arch.

Ont., Windsor—A. H. McPhail, Arch., Board of Trade Bldg., is preparing plans for the construction of a 6 story, 30 x 120 ft. mercantile building on Ouellette Ave., for C. H. Smith Co., Pitt St. A steam heating system will be installed in same. Total estimated cost, $100,000.

B. C., Merritt—Nicola Pine Mills, Ltd., plans to build new saw mills. Steam boilers, engines and saw mill equipment will be installed in same. Estimated cost, $250,000. Work to start as soon as possible.

CONTRACTS AWARDED

Conn., Bristol—The New Departure Manufacturing Corporation, 269 North Main St., has awarded the contract for the construction of a 6 story, 75 x 157 ft. brick and concrete hotel on North Main St., to Ellison Construction Co., 98 Wellington Ave., Hartford. A steam heating system will be installed in same. Total estimated cost, $200,000.

Conn., Hartford—The Hartford Electric Light Co., 266 Pearl St., has awarded the contract for placing high tension suspension line across the Connecticut River, below Dutch Point, to Fred T. Ley, 495 Main St., Springfield, Mass. Contractor will sublet construction of two 160 ft. steel towers. Total estimated cost, $50,000.

R. I., Woonsocket—The Barnai Worsted Co., South Main St., has awarded the contract for the construction of a 1 story, 35 x 130 ft. dye house and a 35 x 40 ft. boiler house, to J. H. Grozier Co., 756 Main St., Hartford, Conn. Total estimated cost, $25,000.

N. Y., Astoria—Glynne & Ward, Alhambra Theatre, Halsey St. and Knickerbocker Ave., Brooklyn, have awarded the contract for the construction of a 2 story theatre here, to H. Shapiro, 52 Vanderbilt Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $400,000. Noted May 13.

N. Y., New York—Baker, Carver & Morrell, 39 Water St., have awarded the contract for building a 9 story, 28 x 83 ft. office at 37 Water St., to C. L. Frazer, 103 Park Ave. A steam heating system will be installed in same. Noted Aug. 5.

N. Y., New York—The Broadway-John St. Corporation, 206 Broadway, has awarded the contract for the construction of a 7 story, 53 x 83 ft. office building at 19-23 Bridge St. through to 2-4 Stone St., to the Fleischman Construction Co., 531 7th Ave. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. Y., New York—Post & Flagg, 28 Wall St., have awarded the contract for the construction of a 6 story, 50 x 100 ft. office building at 49-51 Broad St., to Cauldwell-Wingate, 281 4th Ave. A steam heating system will be installed in same.

N. Y., New York—Street & Smith, 161 West 15th St., have awarded the contract for building a 7 story, 50 x 100 ft. publishing house, to Fountain & Choate, 110 East 23d St. A steam heating system will be installed in same. Total estimated cost, $125,000. Noted July 15.

N. Y., Schenectady—The Gloversville Knitting Mills Co., Gloversville, has awarded the contract for remodelling the Congress St. Theatre, here, for its own use, to Shear & Gordon. A steam heating system and transmission equipment will be installed in same. Total estimated cost, between $25,000 and $35,000.

N. Y., Utica.—The Trustees of the Masonic Home have awarded the contract for the construction of a 4 story, 41 x 54 x 217 ft. memorial hospital on Bleecker St. and Prospect Park, to John F. Hughes Construction Co., 211 Post St. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. J., Camden—The Standard Oil Co., 26 Broadway, New York City, has awarded the contract for the construction of a 4 story, storage plant, to the White Engineering Co., 95 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $600,000.

N. J., Passaic—The General Silk Importing Co., c/o Lockwood, Greene & Co., Archts., 101 Park Ave., New York City, has awarded the contract for the construction of a reinforced concrete factory, to J. W. Ferguson, Paterson. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. J., Red Bank—The Standard Oil Co., 26 Broadway, New York City, has awarded the contract for the construction of a 2 story garage, to the White Engineering Co., 95 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. J., Trenton—Standard Oil Co., 26 Broadway, New York City, has awarded contract for constructing a 3 story storage plant, to the White Engineering Co., 95 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. C., High Point—The Southern Furniture Exposition Building, Inc., has awarded the contract for a 10 story, 100 x 208 ft. building on Main St., to W. P. Rose, Goldsboro, N. C. A steam heating system will be installed in same. Total estimated cost, $450,000.

Ohio, Cleveland—Aetna Rubber Co., 815 East 79th St., has awarded the contract for building a 1 story, 29 x 37 ft. boiler room at 815 East 79th St., to George P. Ford Co., East 40th St. Estimated cost, $6000.

Ohio, Cleveland — The Bamberger-Reinthal Co., 2621 East 9th St., has awarded the contract for building a 3 story, 70 x 180 ft. factory on Grand Ave., to Bolton & Pratt, 801 Columbia Bldg. A steam heating system will be installed in same. Total estimated cost, $100,000.

Wis., Sheboygan—The Haack Motor Co. has awarded the contract for the construction of a 2 story, 63 x 120 ft. garage on 12th St. and Indiana Ave., to C. Haack, Sheboygan. A steam heating system will be installed in same. Total estimated cost, $60,000.

Kan., Wichita—The Board of Education has awarded the contract for installing a steam heating system in the proposed new Emerson School, to the Salina Plumbing Co., Salina. Estimated cost, $20,380.

Mo., St. Louis—M. C. Giles, 4914 Delmar Ave., has awarded the contract for installing heating, plumbing and other miscellaneous work in his dry cleaning plant at 5157 Easton Ave., to the Hoffman Heating Co., 5912 Enright Ave. Estimated cost, $10,000.

Mo., St. Louis—Johansen Bros. Shoe Co., 3646 Laclede Ave., has awarded contract for building a 5 story, 53 x 102 shoe factory on 3646 Laclede Ave,, to Western Construction Co., Central Bldg. A steam heating system and boilers will be installed. Total estimated cost, $50,000.

Okla., Norman—The State Board of Public Affairs, Oklahoma City, has awarded the contract for the construction of a 3 story dormitory, to the Manhattan Construction Co., 3rd and Fondulac St., Muskogee. A steam heating system will be installed in same. Estimated cost, $100,000.

Cal., Los Angeles—The Board of Public Service, 645 South Olive St., has awarded the contract for furnishing generators and electrical equipment for power plant No. 2 in the San Francisco Canyon, to the General Electric Co., 728 South Spring St., at $457,505; furnishing and installing hydro-electrical appliances to Wellman-Seaver-Morgan Co., at $203,561.

Cal., San Marino—Henry E. Huntington has awarded the contract for the construction of a 2 story, 160 x 200 ft. library, to W. C. Crowell, 440 Chamber of Commerce Bldg., Pasadena. A steam heating system will be installed in same. Total estimated cost, $175,000.

Ont., London—C. S. Hyman & Co. has awarded the contract for building a 5 story, 150 x 250 ft. factory on St. George St., to P. H. Secord & Sons, Brantford. Steam heating system, engine, boiler, etc., will be installed in same. Total estimated cost, $200,000. Noted Aug. 5.

Ont., Ottawa—Loew's Theatre, Ltd., has awarded the contract for the construction of a 4 story, 150 x 200 ft. theatre, store and office building on Bank and Queen St., to Bates & McMahon, Central Chambers, Elgin St. A steam heating system will be installed in same. Total estimated cost, $450,000.

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